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A SURVEY OF AVERAGE DRIVING PATTERNS IN THE CINCINNATI URBAN AREA

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A SURVEY OF AVERAGE DRIVING PATTERNS IN THE CINCINNATI URBAN AREA

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September 30, 1969

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Project Manager

INTRODUCTION

System Development Corporation (SDC) has performed a study to survey the characteristic use patterns of privately operated automobiles in the Cincinnati, Ohio urban area. The study was conducted under jointly sponsored research contracts to the National Center for Air Pollution Control, Department of Health, Education, and Welfare, and the Coordinating Research Council, Inc. The purpose of the study was to obtain data necessary to develop a composite average driving pattern that would serve as a basis for designing new test cycles for vehicle emission control devices.

During the study SDC installed automatic information recording devices -- called Tachographs -- in 149 privately operated automobiles volunteered by Cincinnati area residents. The data records from these instruments as well as information obtained from log books maintained by each of the volunteer participants have been reduced and analyzed. This document presents a discussion of the study results, and a comparison of these results with the findings of similar surveys conducted previously in Los Angeles, California and Houston, Texas.

This report is published as Volume II of SDC document series TM-(L)-4119. Volume 0, A Survey of Average Driving Patterns in the Los Angeles Urban Area presents in addition to the Los Angeles survey findings a description of the survey technique as well as the data reduction and statistical analysis procedures. Since the technique and procedures used for collecting and analyzing the Cincinnati data are essentially the same as those employed for Los Angeles, reference is made to Volume 0 for information in these areas.

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RESULTS OF STUDY

This chapter presents the results of the Survey of Average Driving Patterns in the Cincinnati urban area. The results are organized into three sections. The first presents a detailed description of the several average or typical[1] driving patterns that were developed from a statistical analysis of the survey data. The second section presents a summary description of the data base from which the typical patterns were derived. The third section presents a comparison between the Cincinnati results and the results of the surveys carried out previously in Los Angeles and Houston using statistical analytical techniques to determine similarities and differences between the driving habits of the citizens of two cities.

TYPICAL DRIVING PATTERNS

SDC's intent in deriving the typical driving patterns described below has been to extract from a large amount of information collected during the survey a fairly detailed quantitative and qualitative description of those patterns which clearly stand out as typical. While the data base is large, it is not so large that the analyst can, with great confidence, probe very deeply into the intricacies of secondary or tertiary patterns. Nevertheless, in view of the scarcity of previous results in this area of study, particularly from the standpoint of enlisting the public's aid in the data collection effort, the results presented here present a substantial contribution to our knowledge of automobile utilization--even if they only serve to reinforce what have heretofore been intuitive concepts about how people drive their cars.

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[1] SDC prefers the term "typical" to the term "average" since the latter has the connotation of an arithmetic mean which in the present case is not entirely appropriate. The typical driving patterns are, in most aspects of the analysis, derived from modes rather than means in the statistical sense.

A typical driving pattern is described in terms of a day's sequence of trips that all start at approximately the same time, have the same trip segment string (i.e., have identical patterns of freeway and nonfreeway usage), and can be explained by a reasonable scenario of driver behavior. The patterns described below are those which stand out clearly in the results of the analysis. Part of the description of each pattern is an indication of the percentage of the entire survey sample represented by the pattern as well as the percentage of the n-trip sample which is characterized by the n-trip pattern. Figure 1 shows the distribution of n-trip days for the seven days of the week.

Table 1 shows the distribution of complete weekdays and weekend days[1] upon which survey participants drove their cars on n-trips. In the Cintinnati survey, n varied from zero to 17 on weekdays and from zero to 15 on weekends. The table shows that the occurrence of days on which more than five trips were driven drops off quickly compared to days on which five or less were driven. Partly because of the dropoff in sample size as the number of trips increased, but more importantly because the potential number of trip patterns increases geometrically as the number of trips per day increases, patterns were discovered only for two-, three-, four-, and five-trip sequences.

Again, as in Los Angeles and Houston, no clear-cut patterns were discernible for weekend driving. The time distribution of weekend trips is quite different from that of weekday trips (see Figures 12 and 13). To some extent this difference may be more marked in our survey due to the composition of the survey population. All participants in the survey were contacted through their place of employment. Consequently, the daily work schedule imposed

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[1] A complete day is one for which data were obtained for the entire day's operation or for which data on two half-days of operation were available and could be merged to make a single day's operation.

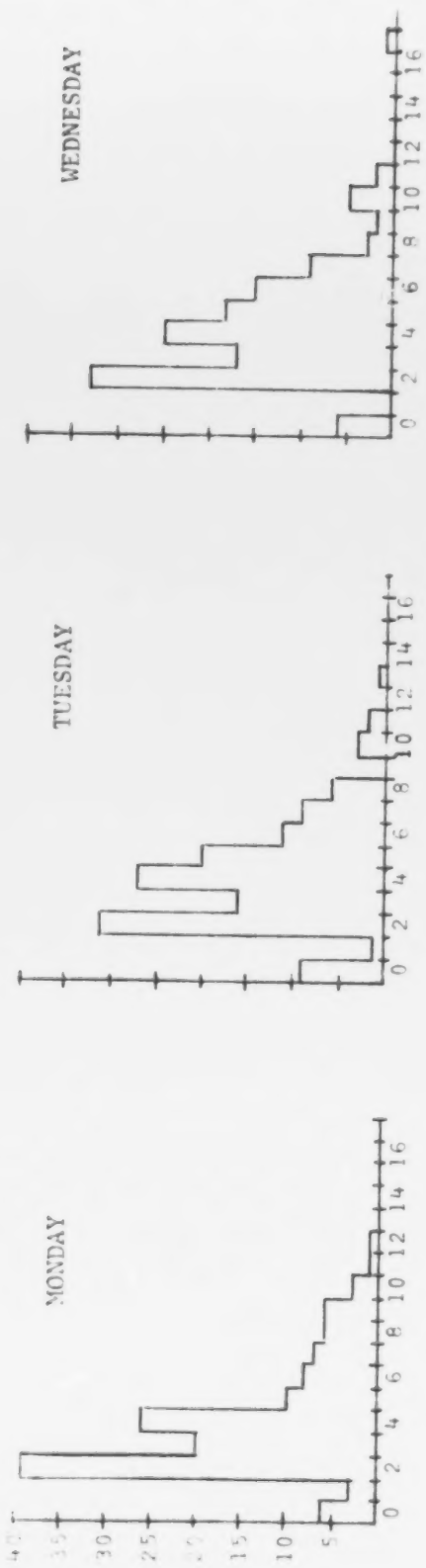

FIGURE 1
FREQUENCY OF N-TRIP DAYS BY DAY OF WEEK

TABLE 1

DAILY DISTRIBUTION OF COMPLETE N-TRIP
DAYS IN CINCINNATI DRIVING PATTERNS SURVEY

NUMBER OF TRIPS PER DAY (N)	NUMBER OF N-TRIP DAYS							
	M	T	W	TH	F	S	S	TOTAL
0	6	9	6	4	5	11	22	63
1	3	1	0	4	0	3	6	44
2	39	31	33	31	20	18	19	191
3	20	16	17	23	18	18	12	124
4	26	27	25	23	24	15	19	159
5	10	20	18	21	22	13	12	116
6	8	11	15	13	15	12	8	82
7	7	9	9	6	11	11	11	64
8	6	6	3	7	8	7	8	45
9	6	0	2	1	2	10	7	28
10	3	3	5	1	3	5	5	25
11	1	2	2.	1	2	8	4	20
12	1	0	0	1	1	4	1	8
13	0	1	0	0	2	0	0	3
14	0	0	0	0	1	0	2	3
15	0	0	0	0	2	1	0	3
16	0	0	0	0	0	0	0	0
17	0	0	1	0	0	0	0	1
TOTAL	136	136	136	136	136	136	136	952

upon a working employee tends to be reflected in the survey results. Weekday-weekend differences are discussed more fully in the General Results section of this chapter.

In analyzing the typical n-trip day patterns, differences in the occurrence of particular trip segment strings require that two alternative trips be considered as components of the pattern in certain cases. Also, two distinct patterns for the four-trip and five-trip days were discovered that require alternative descriptions.

The following sections of the chapter describe each sequence, or pattern, of trips in terms of a scenario and a table of values for such trip descriptors as start time, trip and segment distance, segment average speed, number of momentary stops (idles) per segment, idling time per segment,[1] route types, and purpose of trip. The quantities tabulated for start time, distance, average speed, number of momentary stops (idles), idling time, route type and purpose of trip are the mean values associated with trips and segments that are defined by the specified time slot, purpose, and trip segment string. Adjacent to these values are ranges within which at least 75 percent of the data lie. These ranges are obtained by examining a printout of the distribution of cases for each variable as specified by time slot, purpose, and trip segment string. In the printout, variables are grouped into class intervals. The class intervals used by the program are as follows:

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[1] In the Los Angeles Survey a linear regression model was made to convert number of momentary stops to idling time. Because of the wide variance in measured idle time as a function of number of stops, we expressed reservations about this approach in the Los Angeles report. (See D. H. Kearin, R. L. Lamoureux, A Survey of Average Driving Patterns in the Los Angeles Urban Area, System Development Corporation, TM-(L)-4119/000/01A, June 2, 1969, pp. 1-56, 2-18.) In the Cincinnati analysis, as in the Houston analysis, we have discarded the use of the regression model and have included as idling time only that which was actually recorded on the Tachograph disc (i.e., the summation of all idling periods in excess of 40 seconds). Therefore, in evaluating idle time figures, one must consider both the number of momentary stops, which indicate the extent of short idling periods of indeterminant length, and the mean idling time, which represents the expected value of any extended period of idling.

Distance: 3-mile intervals from 0 miles to 50 miles.
Average speed: 5-mph intervals from 0 mph to 75 mph.
Momentary stops: 2-stop intervals from 0 to 30 stops.
Idling time: 2-minute intervals from 0 to 10 minutes.

To calculate the 75-percent ranges for distance, speed, and idling time, the analyst starts with the class interval that contains the mean, and working away from that interval in both directions, sums the number of cases until he has included at least 75 percent of them. The number he accumulates in each direction depends on the way the data are distributed: For distributions skewed in the lower direction, more cases will be picked up below the mean; for symmetrical distributions, the range will be more balanced. The time slots used for grouping the data were agreed upon earlier by CRC[1] and SDC. Weekdays are divided into eight time slots, weekend-days into six. Table 2 shows the organization of the time slot structure.

TABLE 2

TIME SLOT STRUCTURE USED IN
CINCINNATI DRIVING PATTERNS SURVEY

TIME SLOT NUMBER	TIME PERIOD (24 HOUR CLOCK)	
	WEEKDAY	WEEKEND
1	0000-0559	0000-0829
2	0600-0859	0830-1059
3	0900-1129	1100-1259
4	1130-1329	1330-1759
5	1330-1629	1800-2059
6	1630-1829	2100-2359
7	1830-2059	—
8	2100-2359	—

[1] CRC-APRAC Project Groups CAPF-5 and CAPE-10.

The time distribution of all trip start times is shown in Figures 12 and 13 in the General Results section of this chapter.

The elapsed time for each component trip of a typical trip pattern is based on completing the mean trip or segment distance at the mean average speed. The reason for calculating mean elapsed time from mean distance and mean average speed is twofold. First, as described in the pattern descriptions, certain trip distances are derived artifically so that no data on real elapsed time over these distances are available. Second, and more important, the Tachograph provides distance and elapsed time for each trip from which exact average speed values are calculated. The values of these three variables are, however, continuously distributed from the standpoint of the computer. In order to meet computer storage requirements and to obtain distribution information, these variables must be grouped or classified into the class intervals previously listed. Once this is done, mean speed, mean trip distance and mean elapsed time are no longer functionally related in exact terms since all calculations use the midpoint of the class interval to represent all the values within that interval. Therefore, the authors believe that the average speed and average distance are more "real" intuitively since they are descriptive of actual, not artificial, phenomena that occurred during the survey, and that elapsed time can best be calculated using the mean values for these variables rather than using the mean values for time and distance to calculate mean average speed. Variations over the ranges for distance and speed will, of course, cause differences in the elapsed time of the trip or segment.

A general description of the method used in deriving these patterns is contained in the Statistical Analysis section of Part III of the Los Angeles report.[1] The section on general results that follows the description of the typical trip patterns discusses in greater detail the quantitative basis for the patterns described.

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[1] Ibid., pp. 3-1 to 3-16.

The Two-Trip Day

Figure 2 shows the time dependency distribution of all two-trip weekdays that occurred during the survey period in Cincinnati. The presentation is in the form of a trip-to-trip transition matrix. The matrix is set up as follows: All trips are assigned a time slot value based on the time slot into which one-half or more of the total trip time falls. These time slot values for all trips one and two on two-trip days were analyzed to determine into which cell of the trip-to-trip transition matrix the day's record would be counted. The time slot value for trip one established the row for the entry, the time slot value for trip two established the column. Therefore, if a trip one occurred in time slot two followed by a trip two in time slot six, the record for that day was associated with cell 26 at the intersection of the second row and the sixth column. In addition to the slot dependencies, the analysis also provided counts for purpose-to-purpose dependencies within each time slot cell. It is from these latter dependencies that the literal entries in Figure 2 indicating the typical purpose-to-purpose pairs are obtained. In Figure 2 and subsequent trip-to-trip transition matrices these literal entries are made only for cells with high frequency trip entries and then only if a particular purpose pair stands out.

From Figure 2, we see that the highest frequency count occurs in cell 26 with 78 two-trip days showing the transition. Of these 78, 68 show the purpose-to-purpose combination of a trip one, to work, followed by a trip two, to home. That this is a typical trip pattern is clear. Reinforcement is added by the fact that 20 trips in the adjacent cell 25 as well as nine trips in cell 27 show the same purpose-to-purpose structure. If one assumes that the 20 in cell 25 represent people with early quitting times, say between 4:00 and 4:30 p.m., while the nine in cell 27 represent overtime workers, then the analysis shows that between 68 out of 154 (44%) and 97 out of 154 (63%) of the two-trip days fit our typical pattern. This range represents between 10.0% and 14.2% of the total complete car-weekdays in the survey.

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	0	0	0	16	2	1	0
0600-0859	0	0	0	0	22 W-H	78 W-H	9 W-H	0
0900-1129	1	0	1	1	0	0	0	0
1130-1329	3	1	0	0	2	1	0	0
1330-1629	1	0	0	0	1	1	0	0
1630-1829	6	1	1	1	0	0	0	0
1830-2059	4	4	0	0	0	0	0	0
2100-2359	0	0	0	0	0	0	0	0

TRIP ONE TO TRIP TWO

TOTAL TWO-TRIP WEEKDAYS: 154

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 2

TWO-TRIP WEEKDAY TRANSITION MATRIX

The values for the typical two-trip pattern are shown in Table 3. In the first column, entitled Trip Number, the letter "A" represents a nonfreeway trip while the letter "B" represents a freeway trip. The trip-to-work in time slot two on weekdays is more likely to have a trip segment sequence of nonfreeway only rather than nonfreeway/freeway/nonfreeway (the survey contained 314 of the former, 143 of the latter). However, because a substantial number of work trips in this time period do have the nonfreeway/freeway/nonfreeway configuration, we believe that both should be accounted for. The Cincinnati data tend to indicate that weighting factors of seven-tenths and three-tenths should be assigned respectively to the N and the NFN trip segment string work trips in time slot two. This weighting assignment is also used in the subsequent three-, four-, and five-trip day patterns. The data for return trips home in time slot six are confused by the incidence of return trips from origination points other than work. Realizing that the decision is arbitrary, we have chosen to assign the same structure to the return trip from work that is shown in the morning trip to work. Therefore, the distances shown in Table 3 for the evening trip are the same as those in the morning trip. The average speeds for both trips, however, are those characteristic of the time slot, purpose, and trip segment string described. The elapsed times are calculated from these values. The values for trip stops engine running and idle time are adjusted to be proportional to the average distance traveled.

The Three-Trip Day

Figures 3 and 4 show the two trip-to-trip transition matrices for complete three-trip days in the Cincinnati survey. The matrix in Figure 3 shows the transition from trip one to trip two; that in Figure 4 from trip two to trip three.

The predominant transition in the first matrix is from a first trip in time slot two to a second trip in time slot six. In addition, there is a transition of a secondary importance for the adjacent cell representing a second trip in time slot five. Of the total of 52 trips in cell 26, 27 represent the purpose-

TABLE 3

THE TYPICAL TWO-TRIP DAY PATTERNS

(REPRESENTS 44% - 63% OF ALL TWO TRIP DAYS, 10.0% - 12.4% OF ALL COMPLETE CAR WEEKDAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME MEAN	START TIME RANGE*	MEAN ELAPSED TIME (MIN)	DISTANCE (MILES) MEAN	DISTANCE (MILES) RANGE**	AVERAGE SPEED (MPH) MEAN	AVERAGE SPEED (MPH) RANGE**	NUMBER OF STOPS (MILES) MEAN	NUMBER OF STOPS (MILES) RANGE**	[illegible] MEAN	[illegible] RANGE**
1A	WORK	1	NF	0722	0643 - 0801	21.8	7.5	0.1 - 12.0	20.6	10.0 - 35.0	9.0	4.0 - 14.0	1.2	0.0 - 2.0
	OR:													
1B	WORK	1	NF	0723	0643 - 0803	10.4	4.6	0.1 - 6.0	26.6	10.0 - 40.0	4.8	0.0 - 10.0	0.3	0.0 - 2.0
		2	F			9.8	5.6	0.1 - 9.0	34.2	15.0 - 45.0	0.4	0.0 - 2.0	0.1	0.0 - 1.0
		3	NF			9.0	3.4	0.1 - 6.0	22.7	10.0 - 40.0	3.8	0.0 - 6.0	0.2	0.0 - 1.0
						29.2	13.6				9.0		0.6	
TRIPS 1A AND 1B OCCUR IN THE RATIO OF 7 TO 3 RESPECTIVELY														
2A	HOME	1	NF	1715	1644 - 1746	19.5	7.5	0.1 - 12.0	23.1	10.0 - 30.0	6.5	0.0 - 12.0	0.4	0.0 - 1.0
	OR:													
2B	HOME	1	NF	1702	1635 - 1729	7.4	3.4	0.1 - 6.0	22.7	10.0 - 40.0	5.3	0.0 - 8.0	0.7	0.0 - 1.0
		2	F			9.6	5.6	0.1 - 9.0	35.1	20.0 - 50.0	0.8	0.0 - 2.0	0.2	0.0 - 1.0
		3	NF			10.3	4.6	0.1 - 6.0	26.8	10.0 - 40.0	4.0	0.0 - 8.0	0.6	0.0 - 1.0
						27.3	13.6				10.1			
TRIPS 2A AND 2B OCCUR IN THE RATIO OF 7 TO 3 RESPECTIVELY														

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	1	0	1	4	2	0	1
0600-0859	2	1	5	13	52 W-S	1	0	
0900-1129	2	1	0	1	1	0		
1130-1329	0	1	0	0	1			
1330-1629	0	1	0	0				
1630-1829	2	0	0					
1830-2059	1	0						
2100-2359	0							

TRIP ONE TO TRIP TWO
TOTAL THREE-TRIP WEEKDAYS: 94

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 3

THREE-TRIP WEEKDAY TRANSITION MATRIX

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	0	0	0	0	0	0	0
0600-0859	0	0	0	0	0	3	0	0
0900-1129	1	0	0	1	1	0		
1130-1329	3	2	2	0	0			
1330-1629	10 S-H	6	1	1				
1630-1829	38 S-H	13 S-H	7					
1830-2059	2	1						
2100-2359	2							

TRIP TWO TO TRIP THREE

TOTAL THREE-TRIP WEEKDAYS: 94

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 4

THREE-TRIP WEEKDAY TRANSITION MATRIX

to-purpose transition of work to shopping. In addition, four of the trips in cell 25 also have this pattern. The morning-to-evening, work-to-shopping pattern between trips one and two therefore represents between 29% and 33% of all three-trip days in the Cincinnati survey.

The second matrix, Figure 4, shows the highest frequency of transitions between trips two to three occurring within time slot six. Secondary patterns also occur in cells 55 and 67 which correlate with the overall three-trip day pattern. In cell 66, 27 transitions out of 38 are from shopping to home; in cell 52, seven out of ten; and in cell 67, seven out of 13. Therefore, we believe it reasonable to state that the three-trip day pattern represents at least 29% of the three-trip days (27 out of 94 such days), or 4.0% of the complete car-weekdays in the survey.

Table 4 contains the values describing the typical three-trip day pattern. In calculating results for the trips 2A-3A combinations, the total distance of trip 1A is allocated between trips 2A and 3A in proportion to the mean distances of shopping trips and home trips in time slot six.

The distribution of trip purposes and trip segment string in time slot six provides no grounds for determining whether the evening shopping trip for drivers who use freeways between work and home typically has the configuration of N or NFN. There are 165 of the former and 33 of the latter. The "expected" number[1] of the former is 157 and of the latter is 20. Because there are no clear-cut grounds for decision, two trip combinations are shown in Table 4, labeled 2B1-3B1 and 2B2-3B2. In the first, the shopping trip has the

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[1] The "expected" number is determined by applying a chi-square test to the tableau showing purpose-trip segment string frequencies by time slot. The underlying assumption is that such a test indicates the degree to which purpose-trip segment string combinations depart from independence of time slot. For a more complete explanation, see ibid., p. 1-37, 1-40.

TABLE 4

THE TYPICAL THREE-TRIP DAY PATTERNS

(REPRESENTS 28% OF ALL THREE-TRIP DAYS, 4.0% OF ALL COMPLETE CAR WEEKDAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME MEAN	START TIME RANGE*	MEAN ELAPSED TIME (MIN)	DISTANCE (MILES) MEAN	DISTANCE (MILES) RANGE**	AVERAGE SPEED (MPH) MEAN	AVERAGE SPEED (MPH) RANGE**	NUMBER OF STOPS (IDLES) MEAN	NUMBER OF STOPS (IDLES) RANGE**	IDLE TIME (MIN) MEAN	IDLE TIME (MIN) RANGE**
1A	WORK	1	NF	0722	0643 - 0801	21.8	7.5	0.1 - 12.0	20.6	10.0 - 35.0	9.0	4.0 - 14.0	1.2	0.0 - 2.0
	OR:													
1B	WORK	1	NF	0723	0643 - 0830	10.4	4.6	0.1 - 6.0	26.6	10.0 - 40.0	4.8	0.0 - 10.0	0.3	0.0 - 2.0
		2	F			9.8	5.6	0.1 - 9.0	34.2	15.0 - 45.0	0.4	0.0 - 2.0	0.1	0.0 - 1.0
		3	NF			9.0	3.4	0.1 - 6.0	22.7	10.0 - 40.0	3.8	0.0 - 6.0	0.2	0.0 - 1.0
						29.2	13.6				9.0		0.6	
TRIPS 1A AND 1B OCCUR IN THE RATIO OF 7 TO 3 RESPECTIVELY														
2A	SHOP	1	NF	1722	1647 - 1740	9.1	3.5	0.1 - 6.0	23.0	10.0 - 35.0	4.8	0.0 - 10.0	0.2	0.0 - 1.0
3A	HOME	1	NF	1754	—	10.4	4.0	0.1 - 9.0	23.1	10.0 - 30.0	5.4	0.0 - 10.0	0.3	0.0 - 1.0
	OR:													
2B1	SHOP	1	NF	1722	1647 - 1740	4.4	1.7	0.1 - 3.0	23.0	10.0 - 35.0	2.4	0.0 - 10.0	0.1	0.0 - 1.0
3B1	HOME	1	NF	1749	—	3.7	1.7	0.1 - 3.0	27.7	10.0 - 40.0	2.2	0.0 - 8.0	0.3	0.0 - 1.0
		2	F			9.6	5.6	0.1 - 9.0	35.1	20.0 - 50.0	0.8	0.0 - 2.0	0.2	0.0 - 1.0
		3	NF			10.3	4.6	0.1 - 6.0	26.8	10.0 - 40.0	4.0	0.0 - 8.0	0.6	0.0 - 1.0
						23.6	11.9				7.0		1.1	
	OR:													
2B2	SHOP	1	NF	1704	1632 - 1734	7.3	3.4	0.1 - 6.0	28.1	10.0 - 35.0	2.5	0.0 - 4.0	0.3	0.0 - 1.0
		2	F			9.7	5.6	0.1 - 9.0	34.7	20.0 - 45.0	0.8	0.0 - 2.0	0.2	0.0 - 1.0
		3	NF			4.7	1.9	0.1 - 3.0	24.2	10.0 - 40.0	4.8	0.0 - 8.0	0.5	0.0 - 1.0
						21.7	10.9				8.1		1.0	
3B2	HOME	1	NF	1749	—	7.0	2.7	0.1 - 3.0	23.1	10.0 - 30.0	3.6	0.0 - 8.0	0.2	0.0 - 1.0
TRIP COMBINATIONS 2A-3A, 2B1-3B1, AND 2B2-3B2 OCCUR IN THE RATIO 14 TO 3 TO 3 RESPECTIVELY														

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

configuration N and the subsequent home trip has the configuration NFN. In the second combination, the sequence is reversed: each combination is weighted equally at three-twentieths apiece. In both cases, the distance allocated to the shopping trip is the mean distance for shipping trips with the particular trip segment string shown and within the distance range for that particular segment of the morning work trip of which the shopping trip is a part. The subsequent home trip is assigned a distance equal to the difference between the shopping trip and the morning work-to-home trip. As in the two-trip day, we realize that assigning equal distances to the home-to-work and the work-to-home trip is arbitrary, but there is no better criterion provided by the data.

Given the distance assignments just described, the average speed used in continuing the calculations for each trip combination is that of the particular trip segment string for time slot six. Elapsed times depend on completing the assigned distance at the assigned average speed. Momentary stops and idling times are allocated in the same manner as trip distance. Start times for trips 3A, 3B1 and 3B2 are obtained by adding the mean elapsed time between trips for values under one hour. The value added is 23 minutes. No range is shown for the start time value obtained this way.

The Four-Trip Day

Figures 5 through 7 show the three trip-to-trip transition matrices for the four-trip day. Two typical patterns for the four-trip day were discovered: The first is distinguished by a pair of trips in the evening, the second by a pair of trips during the noon period.

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	2	0	0	5	0	1	0
0600-0859	6	5	11 W-S W-H	14 W-H	64 W-H	2	0	
0900-1129	0	1	1	3	0	0		
1130-1329	2	1	0	0	0			
1330-1629	2	1	0	0				
1630-1829	2	2	0					
1830-2059	0	0						
2100-2359	0							

TRIP ONE TO TRIP TWO
TOTAL FOUR-TRIP WEEKDAYS: 125

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 5

FOUR-TRIP WEEKDAY TRANSITION MATRIX

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	0	0	0	0	0	0	0
0600-0859	0	0	0	0	2	4	2	0
0900-1129	4	0	1	0	0	0	0	0
1130-1329	11 S-W H-W	2	1	0	0	0	0	0
1330-1629	7	7	9	0	1	0	0	0
1630-1829	31 H-S H-R	38 H-S H-R H-C	1	0	0	0	0	0
1830-2059	1	4	1	0	0	0	0	0
2100-2359	0	0	0	0	0	0	0	0

TRIP TWO TO TRIP THREE
TOTAL FOUR-TRIP WEEKDAYS: 125

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 6

FOUR-TRIPWEEKDAY TRANSITION MATRIX

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	0	0	0	0	0	0	0
0600-0859	0	0	0	0	0	0	0	0
0900-1129	0	0	0	0	0	3	1	0
1130-1329	1	0	10 W-H	0	0	0	0	0
1330-1629	5	5	1	1	16 S-H	15 S-H R-H	12 R-H C-H	5
1630-1829	16 S-H	15 S-H R-H	12 R-H C-H	5	28 S-H	22 R-H		
1830-2059	28 S-H	22 R-H	5					
2100-2359	5							

TRIP THREE TO TRIP FOUR

TOTAL FOUR-TRIP WEEKDAYS: 125

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 7

FOUR-TRIP WEEKDAY TRANSITION MATRIX

Evening Pattern

Cell 26 in Figure 5 shows that 64 cars transitioned from time slot two to time slot six. Of these, 47 transitioned from a work trip to a home trip. Turning to Figure 6, we see that these 47 cars were among the 69 cars that transitioned to a third trip in time slots six and seven. These 69 transitions included 26 home-to-shopping trips, eight home-to-school trips and 15 home-to-recreation trips. Figure 7 shows that third trips in time slot six transitioned primarily to fourth trips in time slots six, seven and eight and third trips in time slot seven transitioned to time slots seven and eight. Of the 43 of these fourth trips in time slot six (cell 66), all were return trips from shopping. Of the 15 fourth trips in time slot seven (cells 67 and 77), 29 were return trips from shopping, six were return trips from recreation and three were return trips from school. Of the 34 fourth trips in time slot eight (cells 68 and 78), eight returned from shopping, seven from school and 17 from recreation.

From these data we deduce the typical Four-Trip Day (Evening) Pattern, shown in Table 5. Trip one is to work in time slot two. Trip two returns home in time slot six. Trip three is a shopping, recreation or school trip in time slot six or seven. Trip four returns home in time slot seven or eight. Trips one and two are divided between the two-trip segment structures used in the previous two patterns in the same two-to-one ratio. The trip segment structures of the evening trips are all nonfreeway trips.

The minimum number of car-days that show the typical four-trip evening pattern (using the number of work-to-home trips in cell 26 of Figure 5) is 47. This represents 38% of all four-trip days and 6.9% of all car weekdays in the survey.

TABLE 5

THE TYPICAL FOUR-TRIP DAY (EVENING) PATTERN

(REPRESENTS 38% OF ALL FOUR-TRIP DAYS, 6.9% OF ALL COMPLETE CAR WEEKDAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME		MEAN ELAPSED TIME (MIN)	DISTANCE (MILES)		AVERAGE SPEED (MPH)		NUMBER OF STOPS (IDLES)		IDLE TIME (MIN)	
				MEAN	RANGE*		MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**
1A	WORK	1	NF	0722	0643 - 0801	21.8	7.5	0.1 - 12.0	20.6	10.0 - 35.0	9.0	4.0 - 14.0	1.2	0.0 - 2.0
	OR:													
1B	WORK	1	NF	0723	0643 - 0803	10.4	4.6	0.1 - 6.0	26.6	10.0 - 40.0	4.8	0.0 - 10.0	0.3	0.0 - 2.0
		2	F			9.8	5.6	0.1 - 9.0	34.2	15.0 - 45.0	0.4	0.0 - 2.0	0.1	0.0 - 1.0
		3	NF			9.0	3.4	0.1 - 6.0	22.7	10.0 - 40.0	3.8	0.0 - 6.0	0.2	0.0 - 1.0
						29.2	13.6						0.6	
TRIPS 1A AND 1B OCCUR IN THE RATIO OF 7 TO 3 RESPECTIVELY														
2A	HOME	1	NF	1715	1644 - 1746	19.5	7.5	0.1 - 12.0	23.1	10.0 - 30.0	6.5	0.0 - 12.0	0.4	0.0 - 1.0
	OR:													
2B	HOME	1	NF	1702	1635 - 1729	7.4	3.4	0.1 - 6.0	27.7	10.0 - 40.0	5.3	0.0 - 8.0	0.7	0.0 - 1.0
		2	F			9.6	5.6	0.1 - 9.0	35.1	20.0 - 50.0	0.8	0.0 - 2.0	0.2	0.0 - 1.0
		3	NF			10.3	4.6	0.0 - 6.0	26.8	10.0 - 40.0	4.0	0.0 - 8.0	0.6	0.0 - 1.0
						27.3	13.6				10.1		1.5	
TRIPS 2A AND 2B OCCUR IN THE RATIO OF 7 TO 3 RESPECTIVELY														
3	S,R,C	1	NF	1830	1720 - 1940	8.7	3.4	0.1 - 9.0	23.4	10.0 - 35.0	4.4	0.0 - 10.0	0.4	0.0 - 1.0
4	HOME	1	NF	2033	1906 - 2200	9.8	4.0	0.1 - 9.0	24.4	10.0 - 40.0	3.9	0.0 - 8.0	0.4	0.0 - 1.0

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

Noon Pattern

Cell 24 in Figure 5 shows 11 cars transitioning from a trip in time slot two to a trip in time slot four. Nine of them transition from a first trip to work, five of them to a shopping trip, one to a business trip, and three to a home trip. Under the definition of trip purpose given to survey participants, any of these trips could be to lunch. In Figure 6, cell 44 shows 11 trip twos transitioning to trip threes in time slot four. All of these are return trips to work, seven from shopping, one from business, and three from home.

Cell 46 of Figure 7 shows that 10 third trips in time slot four transition to a fourth trip in time slot six. All of these are from work to home. These data indicate the structure of the typical Four-Trip (Noon) Pattern: trip one is to work, trip two to lunch, trip three back to work, and trip four home in the evening.

The noontime trips are both nonfreeway. The values in Table 6 are obtained by combining and weighting the computed values for the two principal purposes: business and shopping. The morning work trip and the evening return home trip have the same structure as in the other typical patterns and are weighted in the same way.

The minimum number of car-days that showed the Four-Trip Day (Noon) Pattern was nine. This number represents 7% of all four-trip days and 1.3% of all car-days in the sample.

The Five-Trip Day

Figures 8 through 11 contain the trip-to-trip transition matrices for the five-trip day. As noted earlier, as the number of trips per day increases, the number of possible trip-to-trip combinations increases geometrically and the likelihood of detecting a typical pattern decreases. The matrices for the five-trip day require careful study of both time slot and purpose transitions to detect the two typical patterns that are present.

TABLE 6

THE TYPICAL FOUR-TRIP DAY (NOON) PATTERN

(REPRESENTS 7% OF ALL FOUR-TRIP DAYS, 1.3% OF ALL COMPLETE CAR WEEKDAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME MEAN	START TIME RANGE*	MEAN ELAPSED TIME (MIN)	DISTANCE (MILES) MEAN	DISTANCE (MILES) RANGE**	AVERAGE SPEED (MPH) MEAN	AVERAGE SPEED (MPH) RANGE**	NUMBER OF STOPS (IDLES) MEAN	NUMBER OF STOPS (IDLES) RANGE**	IDLE TIME (MIN) MEAN	IDLE TIME (MIN) RANGE**
1A	WORK	1	NF	0722	0643 - 0801	21.8	7.5	0.1 - 12.0	20.6	10.0 - 35.0	9.0	4.0 - 14.0	1.2	0.0 - 2.0
	OR:													
1B	WORK	1	NF	0723	0643 - 0803	10.4	4.5	0.1 - 6.0	26.6	10.0 - 40.0	4.8	0.0 - 10.0	0.3	0.0 - 2.0
		2	F			9.8	5.6	0.1 - 9.0	34.2	15.0 - 45.0	0.4	0.0 - 2.0	0.1	0.0 - 1.0
		3	NF			9.0	3.4	0.1 - 6.0	22.7	10.0 - 40.0	3.8	0.0 - 6.0	0.2	0.0 - 1.0
						29.2	13.6				9.0		0.6	
TRIPS 1A AND 1B OCCUR IN THE RATIO OF 7 TO 3 RESPECTIVELY														
2	S,H,B (LUNCH)	1	NF	1219	1148 - 1240	8.0	3.0	0.1 - 6.0	22.6	10.0 - 35.0	3.8	0.0 - 6.0	0.3	0.0 - 1.0
3	WORK	1	NF	1232	1204 - 1300	9.7	3.7	0.1 - 6.0	22.8	10.0 - 30.0	4.0	0.6 - 6.0	0.2	0.0 - 1.0
4A	HOME	1	NF	1715	1644 - 1746	19.5	7.5	0.1 - 12.0	23.1	10.0 - 30.0	6.5	0.0 - 12.0	0.4	0.0 - 1.0
	OR:													
4B	HOME	1	NF	1702	1635 - 1729	7.4	3.4	0.1 - 6.0	27.7	10.0 - 40.0	5.3	0.0 - 8.0	0.7	0.0 - 1.0
		2	F			9.6	5.6	0.1 - 9.0	35.1	20.0 - 50.0	0.8	0.0 - 2.0	0.2	0.0 - 1.0
		3	NF			10.3	4.6	0.1 - 6.0	26.8	10.0 - 40.0	4.0	0.0 - 8.0	0.6	0.0 - 1.0
						27.3	13.6				10.1		1.5	
TRIPS 4A AND 4B OCCUR IN THE RATIO OF 7 TO 3 RESPECTIVELY														

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	1	3	1	0	2	1	1	0
0600-0859	6	4	8	17 W-H W-S	42 W-H W-S	0	0	
0900-1129	1	0	0	1	0	0		
1130-1329	1	0	0	0	0			
1330-1629	2	0	0	0				
1630-1829	0	0	0					
1830-2059	0	0						
2100-2359	0							

TRIP ONE TO TRIP TWO

TOTAL FIVE-TRIP WEEKDAYS: 91

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 8

FIVE-TRIP WEEKDAY TRANSITION MATRIX

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	1	0	0	0	0	0	0	0
0600-0859	2	0	1	1	5	0	0	
0900-1129	4	1	0	1	0	0		
1130-1329	6	1	2	0	0			
1330-1629	9	8 S-H	4	0				
1630-1829	21 S-H H-S	23 H-S H-R H-C	0					
1830-2059	1	0						
2100-2359	0							

TRIP TWO TO TRIP THREE
TOTAL FIVE-TRIP WEEKDAYS: 91

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 9

FIVE-TRIP WEEKDAY TRANSITION MATRIX

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	0	0	1	0	0	0	0
0600-0859	1	0	0	0	0	0	1	0
0900-1129	2	0	2	0	0	0	0	0
1130-1329	4	1	3	0	0	0	0	0
1330-1629	3	4	4	0	25 H-S H-R S-S	3		
1630-1829	9 H-S	21 S-S S-R E-S	7					
1830-2059								
2100-2359								

TRIP THREE TO TRIP FOUR
TOTAL FIVE-TRIP WEEKDAYS: 91

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 10

FIVE-TRIP WEEKDAY TRANSITION MATRIX

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	0	0	0	0	0	0	0
0600-0859	0	0	0	0	0	1	0	0
0900-1129	0	0	0	0	1	1	0	0
1130-1329	0	0	0	0	0	4	0	1
1330-1629	2	4	0	0	0	7	4	5
1630-1829	7	4	5	0	36 S-H R-H	0	15 R-H S-H	10 R-H S-H
1830-2059	36 S-H R-H	15 R-H S-H	10 R-H S-H	0	0	0	0	0
2100-2359	0	0	0	0	0	0	0	0

TRIP FOUR TO TRIP FIVE
TOTAL FIVE-TRIP WEEKDAYS: 91

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 11

FIVE TRIP-WEEKDAY TRANSITION MATRIX

Evening Pattern

Of the 42 transitions in cell 26 of Figure 8, 24 are from work trips in time slot two to home trips in time slot six. Nine of the 17 transitions in the adjacent cell 25 have a similar purpose-to-purpose pattern. In Figure 9, 18 of the 44 transitions in cells 66 and 67 are from home to shopping, recreation or school. In addition, four of the 17 transitions in cells 55 and 56 are also from home-to-shopping. Of the 46 trips three to trip four transitions in cells 67 and 77 of Figure 10, 23 are between various combinations of shopping, school and recreation. Finally, in Figure 11, 47 of the 51 transitions in cells 77 and 78 are from shopping, school or recreation to home.

From these transitions we deduce the Five-Trip (Evening) Pattern. A first trip to work in time slot two, a return trip home in time slot six (or late in time slot five), a shopping, recreation or school trip in time slot six or seven followed by another in time slot seven, and finally a return home in time slot seven or eight.

The minimum number of cars that followed this pattern in Cincinnati was 18 (using the number that transitioned from a second trip home in time slot six to a third trip in time slot six or seven from shopping, school or recreation). This figure represents 20% of all the five-trip days and 2.6% of all the complete car-weekdays in the Cincinnati survey.

Work-Shop Pattern

Twelve of the transitions in cells 25 and 26 in Figure 8 are from a morning work trip to an evening shopping trip. Cells 56 and 66 of Figure 9 contain nine transitions from shopping trips to home trips. In Figure 10, cells 66 and 67 contain 18 transitions from home trips to shopping and recreation trips. Finally, the frequency of transitions from shopping and recreation trips to home trips in Figure 11 is as discussed in the previous pattern. These data show the nature of the typical Five-Trip (Work-Shop) Pattern--

trip one to work in time slot two, trip two to shop in time slot six (or late in time slot five), trip three a trip home in time slot six, trip four a shopping or recreation trip in either time slot six or seven, and trip five to return home in time slot seven or eight.

The minimum number of cars that followed this pattern in Cincinnati was nine. This number represents 10% of all five-trip days and 1.3% of all complete car-weekdays in the survey.

TABLE 7

THE TYPICAL FIVE-TRIP DAY (EVENING) PATTERNS

(REPRESENTS 20% OF ALL FIVE-TRIP DAYS, 2.6% OF ALL COMPLETE CAR DAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME		MEAN ELAPSED TIME (MIN)	DISTANCE (MILES)		AVERAGE SPEED (MPH)		NUMBER OF STOPS (IDLES)		IDLE TIME (MIN)	
				MEAN	RANGE*		MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**
1A	WORK	1	NF	0722	0643 - 0801	21.8	7.5	0.1 - 12.0	20.6	10.0 - 35.0	9.0	4.0 - 14.0	1.2	0.0 - 2.0
	OR:													
1B	WORK	1	NF	0723	0643 - 0803	10.4	4.6	0.1 - 6.0	26.6	10.0 - 40.0	4.8	0.0 - 10.0	0.3	0.0 - 2.0
		2	F			9.8	5.6	0.1 - 9.0	34.2	15.0 - 45.0	0.4	0.0 - 2.0	0.1	0.0 - 1.0
		3	NF			9.0	3.4	0.1 - 6.0	22.7	10.0 - 40.0	3.8	0.0 - 6.0	0.2	0.0 - 1.0
						29.2	13.6				9.0		0.6	
TRIPS 1A AND 1B OCCUR IN THE RATIO OF 7 TO 3 RESPECTIVELY														
2A	HOME	1	NF	1715	1644 - 1746	19.5	7.5	0.1 - 12.0	23.1	10.0 - 30.0	6.5	0.0 - 12.0	0.4	0.0 - 1.0
	OR:													
2B	HOME	1	NF	1702	1635 - 1729	7.4	3.4	0.1 - 6.0	27.7	10.0 - 40.0	5.3	0.0 - 8.0	0.7	0.0 - 1.0
		2	F			9.6	5.6	0.1 - 9.0	35.1	20.0 - 50.0	0.8	0.0 - 2.0	0.2	0.0 - 1.0
		3	NF			10.3	4.6	0.1 - 6.0	26.8	10.0 - 40.0	4.0	0.0 - 8.0	0.6	0.0 - 1.0
						27.3	13.6				10.1		1.5	
TRIPS 2A AND 2B OCCUR IN THE RATIO OF 7 TO 3 RESPECTIVELY														
3	S,C,R	1	NF	1830	1720 - 1940	8.7	3.4	0.1 - 9.0	23.4	10.0 - 35.0	4.4	0.0 - 10.0	0.4	0.0 - 1.0
4	S,R	1	NF	1924	1844 - 2004	7.1	2.8	0.1 - 6.0	23.8	10.0 - 35.0	3.2	0.0 - 6.0	0.4	0.0 - 1.0
5	HOME	1	NF	2033	1906 - 2200	9.8	4.0	0.1 - 9.0	24.4	10.0 - 40.0	3.9	0.0 - 8.0	0.4	0.0 - 1.0

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

TABLE 8

THE TYPICAL FIVE-TRIP DAY (WORK-SHOP) PATTERNS

(REPRESENTS 10% OF ALL FIVE-TRIP DAYS, 1.3% OF ALL COMPLETE CAR DAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME		MEAN ELAPSED TIME (MIN)	DISTANCE (MILES)		AVERAGE SPEED (MPH)		NUMBER OF STOPS (IDLES)		IDLE TIME (MIN)	
				MEAN	RANGE*		MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**
1A	WORK	1	NF	0722	0643 - 0801	21.8	7.5	0.1 - 12.0	20.6	10.0 - 35.0	9.0	4.0 - 14.0	1.2	0.0 - 2.0
	OR:													
1B	WORK	1	NF	0723	0643 - 0803	10.4	4.6	0.1 - 6.0	26.6	10.0 - 40.0	4.8	0.0 - 10.0	0.3	0.0 - 2.0
		2	F			9.8	5.6	0.1 - 9.0	34.2	15.0 - 45.0	0.4	0.0 - 2.0	0.1	0.0 - 1.0
		3	NF			9.0	3.4	0.1 - 6.0	22.7	10.0 - 40.0	3.8	0.0 - 6.0	0.2	0.0 - 1.0
						29.2	13.6				9.0		0.6	
TRIPS 1A and 1B OCCUR IN THE RATIO OF 7 TO 3 RESPECTIVELY														
2A	SHOP	1	NF	1722	1647 - 1740	9.1	3.5	0.1 - 6.0	23.0	10.0 - 35.0	4.8	0.0 - 10.0	0.2	0.0 - 1.0
3A	HOME	1	NF	1754	–	10.4	4.0	0.1 - 9.0	23.1	10.0 - 30.0	5.4	0.0 - 10.0	0.0	0.0 - 1.0
	OR:													
2B1	SHOP	1	NF	1722	1647 - 1740	4.4	1.7	0.1 - 3.0	23.0	10.0 - 35.0	2.4	0.0 - 10.0	0.1	0.0 - 1.0
3B1	HOME	1	NF	1750	–	3.7	1.7	0.1 - 3.0	27.7	10.0 - 40.0	2.2	0.0 - 8.0	0.3	0.0 - 1.0
		2	F			9.6	5.6	0.1 - 9.0	35.1	20.0 - 50.0	0.8	0.0 - 2.0	0.2	0.0 - 1.0
		3	NF			10.3	4.6	0.1 - 6.0	26.8	10.0 - 40.0	4.8	0.0 - 8.0	0.6	0.0 - 1.0
						23.6	11.9				7.0		1.1	
	OR:													
2B2	SHOP	1	NF	1704	1632 - 1734	7.3	3.4	0.1 - 6.0	28.1	10.0 - 35.0	2.5	0.0 - 4.0	0.3	0.0 - 1.0
		2	F			9.7	5.6	0.1 - 6.0	34.7	20.0 - 45.0	0.8	0.0 - 2.0	0.2	0.0 - 1.0
		3	NF			4.7	1.9	0.1 - 3.0	24.2	10.0 - 40.0	4.8	0.0 - 8.0	0.5	0.0 - 1.0
						21.7	10.9				8.1		1.0	
3B2	HOME	1	NF	1749	–	7.0	2.7	0.1 - 3.0	23.1	10.0 - 30.0	3.6	0.0 - 8.0	0.2	0.0 - 1.0
TRIP COMBINATIONS 2A-3A, 2B1-3B1 AND 2B2-3B2 OCCUR IN THE RATIO 14 TO 3 TO 3 RESPECTIVELY														
4	S,C,R	1	NF	1830	1720 - 1940	8.7	3.4	0.1 - 9.0	23.4	10.0 - 35.0	4.4	0.0 - 10.0	0.4	0.0 - 1.0
5	HOME	1	NF	2033	1906 - 2200	9.8	4.0	0.1 - 9.0	24.4	10.0 - 40.0	3.9	0.0 - 8.0	0.4	0.0 - 1.0

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

GENERAL RESULTS

This section contains a discussion of additional results of the study including a description of the sample, an analysis of daily variations in the data, and an analysis of the individual trip and segment variables as they are affected by such factors as time of day, trip purpose, and type of route used.

The Cincinnati Sample

During the Cincinnati survey, SDC installed Tachographs in 149 automobiles. For various reasons, described more fully in the Appendix to this report, data from 13 of these installations were totally unusable. The results of this study, then, are based on data from 136 automobiles driven in the Cincinnati metropolitan area during the period March 3, 1969 to April 2, 1969. A total of 952 complete car-days are included in the sample. During these trips, participants drove almost 26,000 miles. The average daily distance driven by each participant was 27 miles, during an average of 4.5 trips per day which required an average of one hour and seven minutes of travel time during each day.

Sample Biases

As discussed in Volume 0, Part II of this report, the method used in selecting survey participants biased the sample toward working members of the overall population. In view of this bias, SDC expected that work-related trips would constitute a major component of the resultant typical trip patterns described in the previous section. There is no doubt in our minds that such work-related utilization represents a major, if not the major, component of the overall utilization pattern in the Cincinnati urban area. The sample was made up of participants from all levels of the corporate structure within the participating firms, and the firms represented a reasonable cross-section, in terms of size, of all firms in the area. The results of the survey, therefore, represent a good cross-section of driving behavior within the industrial and commercial sector of the community.

A second bias which has been suggested is that the cars which participated in the survey, being primarily used for transportation to and from work, were not the types of cars people would use for extended trips on weekends or holidays. This would, according to those supporting this theory, explain the somewhat low incidence of long trips and the increased number of zero-trip days on weekends. This argument is bolstered by the fact that SDC chose to exclude station wagons, campers, and pickup trucks from the survey because of certain difficulties inherent in the installation of Tachographs in these vehicles. In the case of Cincinnati this argument is somewhat weakened by the increased trip generation rate on weekends compared to weekdays, 4.8 trips per day on weekends versus 4.3 trips per day on weekdays. These rates are based on all car-days whether or not trips were actually taken on each day. The trip generation rate among cars actually driven in Cincinnati was 5.5 trips per day on weekends versus 4.5 trips per day on weekdays.

The logistics involved in installing Tachographs in the survey cars required a correction in the survey results to compensate for inconsistencies in the data. The instruments were installed during the morning and afternoon of the first survey day for each car. They were removed during the morning of the eighth day. As a result, the data collected during each car's week represented eight calendar days, but the first and eighth days each contained only about a half-day's worth of data. In order to remove this "half-day" bias which would certainly affect the daily pattern of automobile usage reflected in the results of the survey, data from the last half of the first day and from the first half of the eighth day were combined during the data reduction process. In no case was there an overlap of trips on the two combined days that would cause the loss of a trip in the final results. In Cincinnati there were also no cases in which data from one of the two days was unusable for one reason or another (failure of the Tachograph, errors in the recorded data, etc.).

Data Collected

The Tachograph instrument provided data indicating the day of the survey, trip and trip segment[1] start times and complete times, trip and segment distance traveled, length of periods of idling time in excess of 40 seconds, number of momentary stops, and type of road (freeway, nonfreeway) traveled for each segment. Information contained in the log book kept by the driver indicated the date, the purpose of each trip, geographic zone within which each trip started, type of location from which each trip started, road conditions, driver sex and age, whether the car was parked indoors or out at the end of each trip, and the fuel gauge reading at the start of each day. To these data we added various identifying and categorizing variables during the data reduction process so that the final record on each trip contains at least 54 separate data items.

Daily Patterns

Two classifications of the survey data were made in the analysis. First, data were segregated into two groups by weekday and weekend day. The latter included only Saturday and Sunday. Second, the data were segregated into seven groups by day of the week. The latter was done at the request of CRC[2] to enable an examination of any daily variation that may occur.

The data base for the Cincinnati survey contains 650 active car-weekdays and 239 active car-weekend days. To these sums must be added zero-trip days that occurred but are not contained in the data base: 30 car-weekdays and 33 car-weekend days. The resulting totals are 680 car-weekdays and 232 car-weekend days. Table 9 shows the daily breakdown of the sample into active and inactive car days.

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[1] A trip segment is defined as that portion of a trip driven over a single type of road, either freeway or nonfreeway.

[2] CRC-APRAC Project Groups CAPE-5 and CAPE-10.

TABLE 9

DAILY SAMPLE SIZE IN CAR-DAYS

DAY	NUMBER OF CAR-DAYS IN SAMPLE		
	ACTIVE	INACTIVE (0-TRIP)	TOTAL
MONDAY	130	6	136
TUESDAY	127	9	136
WEDNESDAY	130	6	136
THURSDAY	132	4	136
FRIDAY	131	5	136
SATURDAY	125	11	136
SUNDAY	114	22	136

During the survey period, participants drove 4249 valid trips. These were divided into 2933 weekday trips and 1316 weekend trips. Tables 10 and 11 show the daily distribution by time slot of these trips as well as the weekday and weekend total distributions. Figure 12 presents a more detailed time distribution of weekday trip start times by 15-minute intervals. Figure 13 presents similar data for weekend trip start times.

Trip generation rates for active weekdays are 4.51 trips driven per day (i.e., including only those days on which trips were actually taken) and 4.31 trips per day for all days (i.e., including zero-trip days). On weekends, these rates are 5.51 and 4.84 trips per day respectively. The larger difference between the last two numbers reflects the greater likelihood of a zero-trip day on a Saturday or Sunday.

An analytical tool that assisted greatly in determining trip pattern relationships is the trip-to-trip transition matrix. It is a tableau showing the incidence of various trip-related dependencies between successive trips. In order to examine weekday-weekend and daily variations, summary two-step,

TABLE 10

TIME DISTRIBUTION OF WEEKDAY

TRIPS BY DAY AND TIME SLOT

DAY	TIME SLOT								
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	DAILY TOTAL
MONDAY	16	94	35	47	73	137	101	44	547
TUESDAY	16	108	24	34	67	164	103	45	561
WEDNESDAY	16	119	28	45	72	161	103	48	592
THURSDAY	13	117	16	42	70	140	110	42	550
FRIDAY	14	104	42	49	79	182	158	55	683
WEEKDAY TOTAL	75	542	145	217	361	784	575	234	2933

TABLE 11

TIME DISTRIBUTION OF WEEKEND

TRIPS BY DAY AND TIME SLOT

DAY	TIME SLOT						
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	DAILY TOTAL
SATURDAY	81	93	118	229	139	54	714
SUNDAY	61	100	111	203	93	34	602
WEEKEND TOTAL	142	193	229	432	232	88	1316

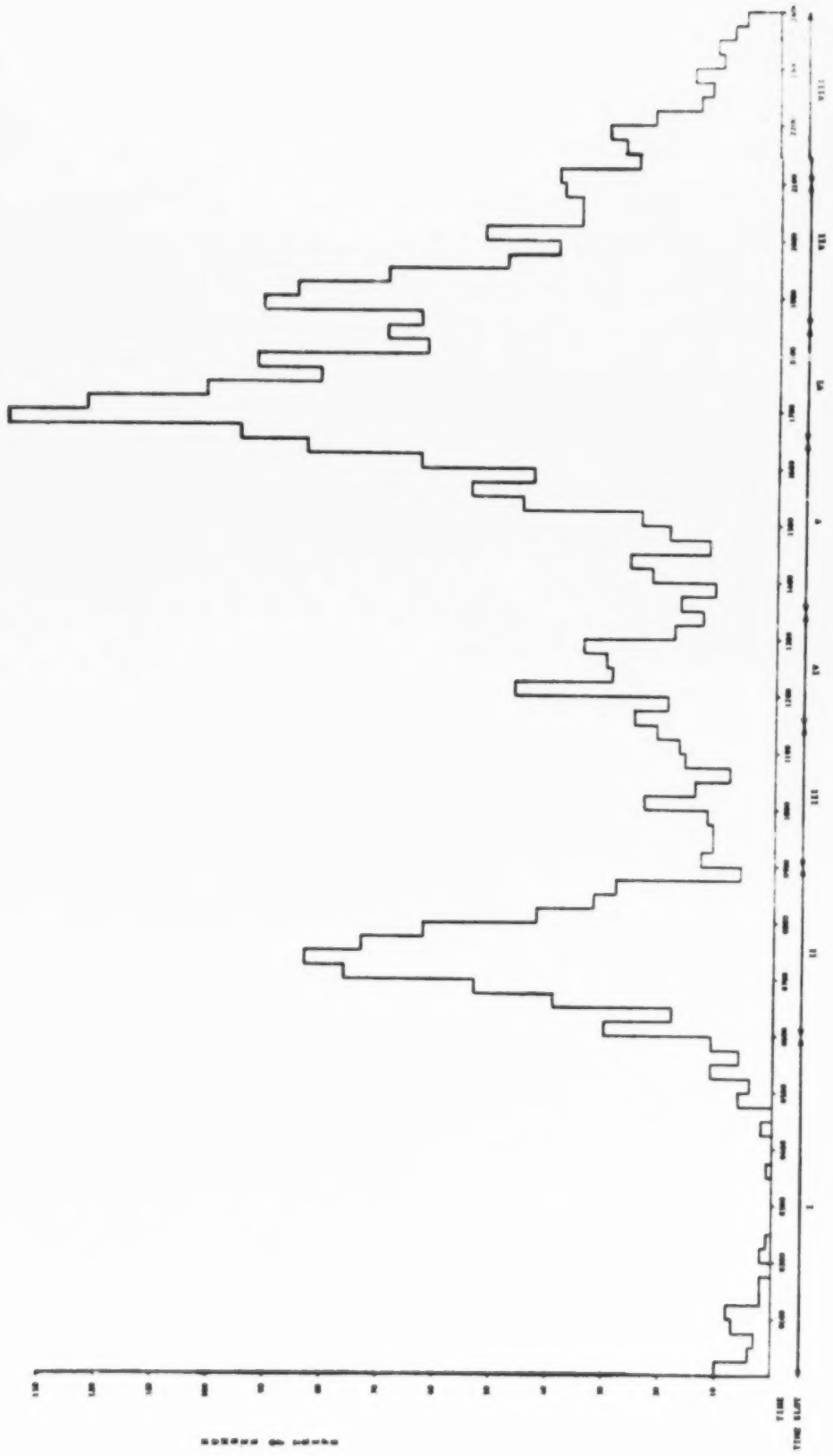


FIGURE 12

DISTRIBUTION OF WEEKDAY TRIP START TIMES

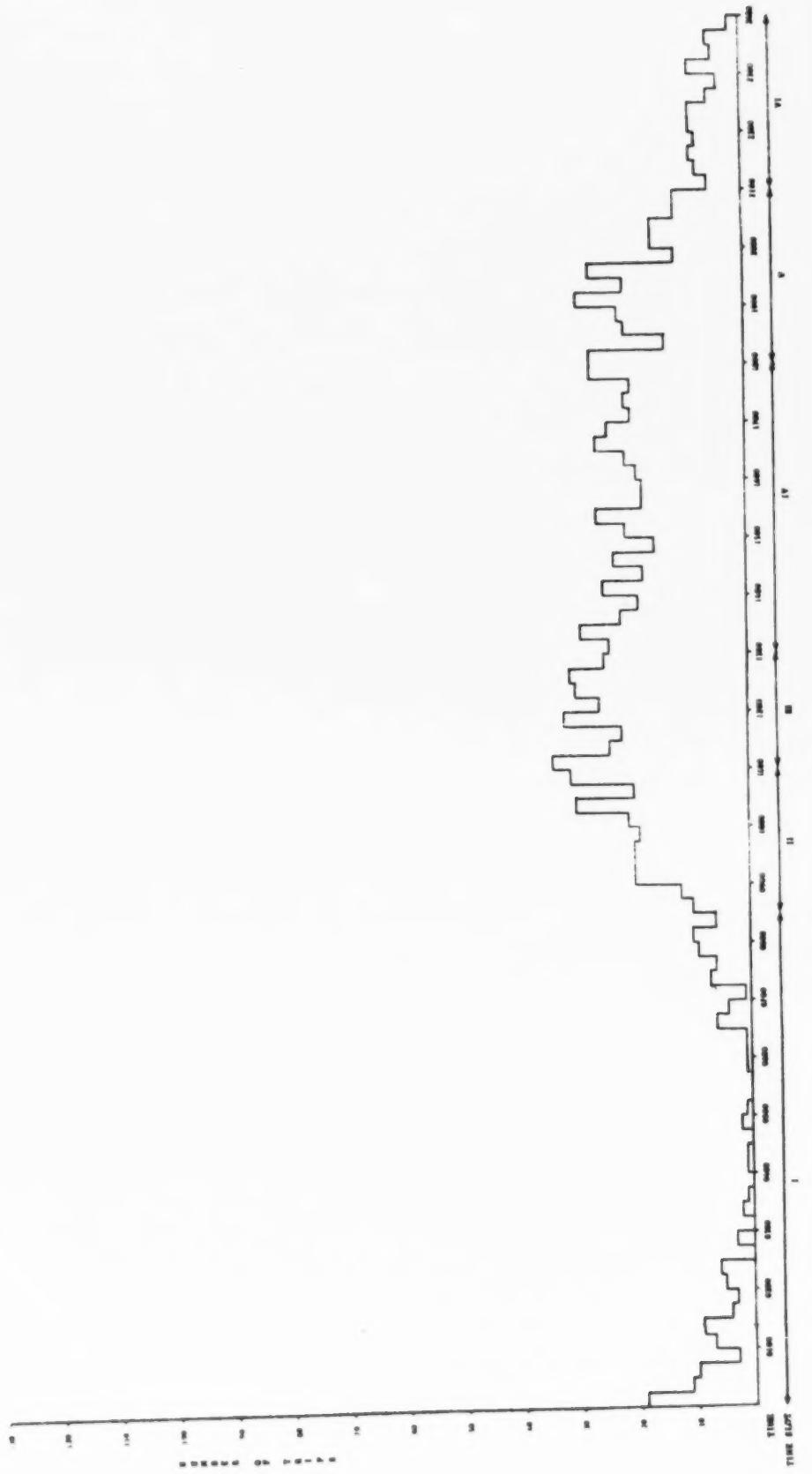


FIGURE 13

DISTRIBUTION OF WEEKEND TRIP START TIMES

trip-to-trip transition matrices were assembled for all trips. Figures 14 and 15 are simplified versions of these matrices. The weekday matrix, of which only the upper right-hand triangle is shown, is divided into nine rows and eight columns. Rows two through nine and columns one through eight correspond to the eight weekday time slots. The first row is called the zero row and corresponds to any time slot on the previous day. A trip in the $j^{\underline{th}}$ time slot of any weekday that was preceded by a trip in the $i^{\underline{th}}$ time slot is tabulated in cell ij where i denotes the row and j denotes the column of the transition matrix. If a previous trip took place on the preceding day, the trip is tabulated in zero row in the column appropriate to its own time slot. In the original matrix, the purpose-to-purpose transition is also shown. We have simplified the matrix in Figure 14 by showing only the modal or typical purpose pattern(s) in cells that have high frequency counts. Figure 15 shows the matrix for weekend trips. This matrix is a seven-by-six matrix due to the reduced number of time slots on weekdays. The literal coded entries in certain cells indicate purpose-to-purpose transitions that clearly stand out as typifying the particular time slot transition.

A final analytical tool used to evaluate daily variation in trip patterns is a two-way contingency table showing the incidence of particular trip purpose and trip segment string combinations in each time slot. These tables were prepared for weekday, weekend, and daily breakdowns of the data. Chi-square tableaux were prepared for each of these tables to see which purpose stood out as typical for each time slot. In these tableaux, an "expected" frequency count is compiled for each cell by reallocating each column total over the cells in that column in proportion to the row totals. The assumption behind this computation is that row and column effects do not interact to affect the cell totals. In the case at hand, it is clear that these effects do interact (e.g., there is more likelihood of a go-to-work trip being taken in time slot two than in time slot eight). Because there is interaction, the differences between the actual cell counts and the "expected" cell counts obtained by

FROM TIME SLOT		TO TIME SLOT: 0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
	PREVIOUS DAY	51	486 H-W	32	15	13	19	9	0
0000-0559		14	17	5	5	30	5	3	1
0600-0859			39	43	56 W-S	105 W-H W-S	288 W-H W-S	15	0
0900-1129				65	37	15	21	6	0
1130-1329					104 S-W	59	43	1	4
1330-1629						139 S-H S-S	118 S-H W-H H-S	32	4
1630-1829							290 S-H H-S	243 H-S S-H H-R S-S	44
1830-2059								266 S-H S-S R-H	117 R-H S-H R-R
2100-2359									64 R-H S-H

TOTAL WEEKDAY TRIPS: 2933

LEGEND

H - Home
W - Work
B - Business
S - Shopping
C - Church, School, etc.
R - Recreation

FIGURE 14

TWO-STEP TRIP-TO-TRIP

TRANSITION MATRIX, ALL WEEKDAY TRIPS

FROM TIME SLOT	TO TIME SLOT: PREVIOUS DAY	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359
	PREVIOUS DAY	95 R-H H-W H-S	69 H-S H-C	31	33	9	2
	0000-0829	47	38	22	28	3	0
	0830-1059	86 S-H S-S C-H	75 C-H S-H S-S	18	5	0	
	1100-1259	101 S-H S-S H-S	97 S-H S-S H-S	12	2		
	1300-1759	256 S-H S-S H-S R-H	101 H-R S-H S-S	10			
	1800-2059	102 S-H R-H	47 R-H R-R				
	2100-2359	27					

TOTAL WEEKEND TRIPS: 1316

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 15

TWO-STEP TRIP-TO-TRIP

TRANSITION MATRIX, ALL WEEKEND TRIPS

computation indicate which purpose or trip segment string (row) is typical of the time slot. Tables 12 and 13 show the purpose-time slot contingency tables for weekday and weekend trips. "Expected" frequency counts for each cell are shown in italics below the actual frequency counts. Within the frequency table, the characteristic purpose(s) for each time slot is indicated by underlining the cell count we consider typical.

An analysis of the individual weekday tables compared to the total weekday table in terms of percentage was carried out using the chi-square test. The purpose of the analysis was to detect any significant daily variation in the time slot distribution of trips or in the purpose distribution. The significance level of 0.95 was used. Results of the test showed that the seven weekdays constituted homogeneous samples with respect to both time slot and purpose distributions.

The time slot distribution of trip segment string is shown in Table 14 for weekday trips and in Table 15 for weekend trips. "Expected" frequencies are again shown in italics. The weekday figures indicate an interesting concentration of freeway utilization in the morning hours when compared to the "expectations." The disparity between actual and "expected" frequencies does not recur to the same extent during the evening rush hour even though there are similarly large numbers of trips that use freeways. No doubt this is indicative of the high likelihood that a trip to or from work will use freeways for part of its completion. During the morning hours, especially in time slot two, trips to work constitute such a major portion of all traffic that anything characteristic of them will dominate the statistics of the period. On weekends the use of freeways is diminished both in frequency and in comparison between actual and "expected" frequency in all but the first time slot.

TABLE 12

ACTUAL AND "EXPECTED" FREQUENCIES OF TRIP PURPOSE
BY TIME SLOT FOR WEEKDAY TRIPS
CHARACTERISTIC TIME SLOT PURPOSES UNDERLINED

TIME SLOT / PURPOSE	I 0000-0559	II 0600-0859	III 0900-1129	IV 1130-1329	V 1330-1629	VI 1630-1829	VII 1830-2059	VIII 2100-2359	TOTALS
GO HOME	33 / *27*	9 / *198*	28 / *53*	42 / *79*	147 / *132*	430 / *286*	229 / *210*	151 / *85*	1069
GO TO WORK	28 / *17*	471 / *122*	32 / *33*	60 / *49*	39 / *81*	28 / *177*	2 / *130*	2 / *53*	662
BUSINESS	5 / *4*	24 / *32*	28 / *9*	17 / *13*	28 / *22*	41 / *47*	25 / *34*	8 / *14*	176
SHOP	5 / *17*	28 / *124*	42 / *33*	85 / *50*	107 / *82*	202 / *179*	181 / *131*	19 / *53*	669
SCHOOL	0 / *2*	5 / *13*	5 / *4*	4 / *5*	8 / *9*	24 / *19*	24 / *14*	1 / *6*	71
RECREATION	4 / *7*	5 / *53*	10 / *14*	9 / *21*	32 / *35*	59 / *76*	114 / *56*	53 / *23*	286
TOTALS	75	542	145	217	361	784	575	234	2933

ACTUAL FREQUENCY
"EXPECTED" FREQUENCY (IN ITALICS)

TABLE 13

ACTUAL AND "EXPECTED" FREQUENCIES OF TRIP PURPOSE
BY TIME SLOT FOR WEEKEND TRIPS
CHARACTERISTIC TIME SLOT PURPOSES UNDERLINED

PURPOSE \ TIME SLOT	I 0000-0829	II 0830-1059	III 1100-1259	IV 1300-1759	V 1800-2059	IV 2100-2359	TOTALS
GO HOME	53 52	48 70	76 83	163 158	87 85	53 32	480
GO TO WORK	28 7	11 9	6 11	13 20	2 11	1 4	61
BUSINESS	12 7	12 9	10 11	18 20	7 11	2 4	61
SHOPPING	26 42	63 57	90 68	161 129	45 69	7 26	392
SCHOOL	7 8	35 11	18 13	9 24	5 13	0 5	74
RECREATION	16 27	24 36	29 43	68 81	86 44	25 16	248
TOTALS	142	193	229	432	232	88	1316

ACTUAL FREQUENCY
"EXPECTED" FREQUENCY

TABLE 14

ACTUAL AND "EXPECTED" FREQUENCIES OF TRIP SEGMENT STRING BY TIME SLOT FOR WEEKDAYS

TRIP SEGMENT STRING	TIME SLOT								TOTALS
	0000-0559	0600-0859	0800-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
N	51 60	367 436	123 116	207 174	301 290	614 630	494 460	200 288	2357
NFN	21 14	160 98	21 26	7 39	52 65	159 141	76 103	32 40	528
NFNFN	3 1	14 7	0 2	1 3	6 5	9 10	4 8	2 3	39
OTHER	0 0	1 2	1 0	2 1	2 1	2 2	2 3	0 1	9
TOTALS	75	542	145	217	361	784	636	234	2933

ACTUAL FREQUENCY

"EXPECTED" FREQUENCY

N = NONFREEWAY SEGMENT

F = FREEWAY SEGMENT

TABLE 15

ACTUAL AND "EXPECTED" FREQUENCIES OF TRIP SEGMENT STRING BY TIME SLOT FOR WEEKENDS

TRIP SEGMENT STRING	TIME SLOT						TOTALS
	0000-0829	0830-1059	1100-1259	1300-1359	1900-2059	2100-2359	
N	113 122	169 166	196 197	376 372	202 199	76 76	1132
NFN	26 17	18 24	30 25	50 53	27 29	11 11	162
NFNFN	3 2	4 3	3 3	5 5	3 3	1 1	19
OTHER	0 0	2 0	0 1	1 1	0 1	0 0	3
TOTALS	142	193	229	432	230	88	1316

ACTUAL FREQUENCY

"EXPECTED" FREQUENCY

N = NONFREEWAY SEGMENT

F = FREEWAY SEGMENT

Trip Descriptors

The discussion of general results so far has dealt with the incidence of variables that can only be counted. These variables essentially define cases under which we wish to examine the behavior of such trip-descriptive variables as distance, elapsed time, velocity, number of stops with engine on and off, and idling time. The present section is devoted to a detailed examination of these variables.

Trip and Segment Distance

The average distance per trip driven during the survey was 6.07 miles. This number is deceptive, however. The distribution of trip distances understandably shows a wide range as is indicated in Figure 16, Distribution of Weekday Trip Distance, and in Figure 17, Distribution of Weekend Trip Distance. Of more particular interest is the time distribution of distance with respect to trip segment string. Tables 16 and 17 show the time slot distribution of number of trips by trip segment string for weekday and weekend respectively along with the average trip distance for each type of trip during the time slot. Tables 18 and 19 show the distribution of segment distance by time slot for nonfreeway and freeway segments associated with freeway trips on weekdays and weekend days.

The data in Figures 16 and 17 are arbitrarily cut off above 28 miles. Nevertheless, these figures account for 98.6% of all weekday trips and 97.5% of all weekend trips.

Trip and Segment Velocity

The distribution of trip velocity, as shown in Figure 18 for weekdays and in Figure 19 for weekends, is unimodal in both cases (i.e., single peaked). The weekend distribution is, however, slightly more spread as indicated by its larger standard deviation, 11.2 versus 9.8 for weekday trips. There is a statistically significant difference in the two means. The 95% confidence

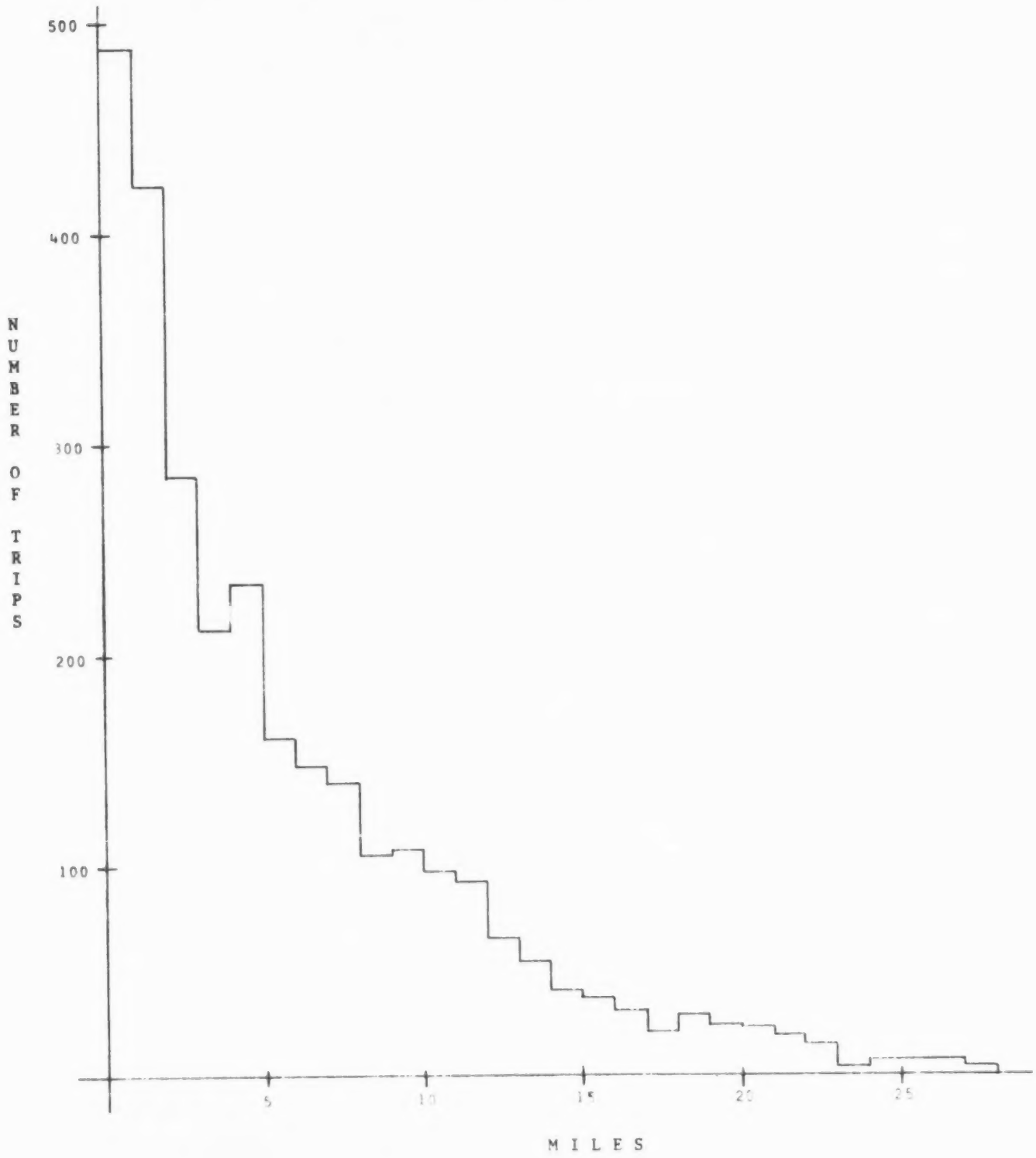


FIGURE 16

DISTRIBUTION OF TRIP DISTANCE, WEEKDAY TRIPS

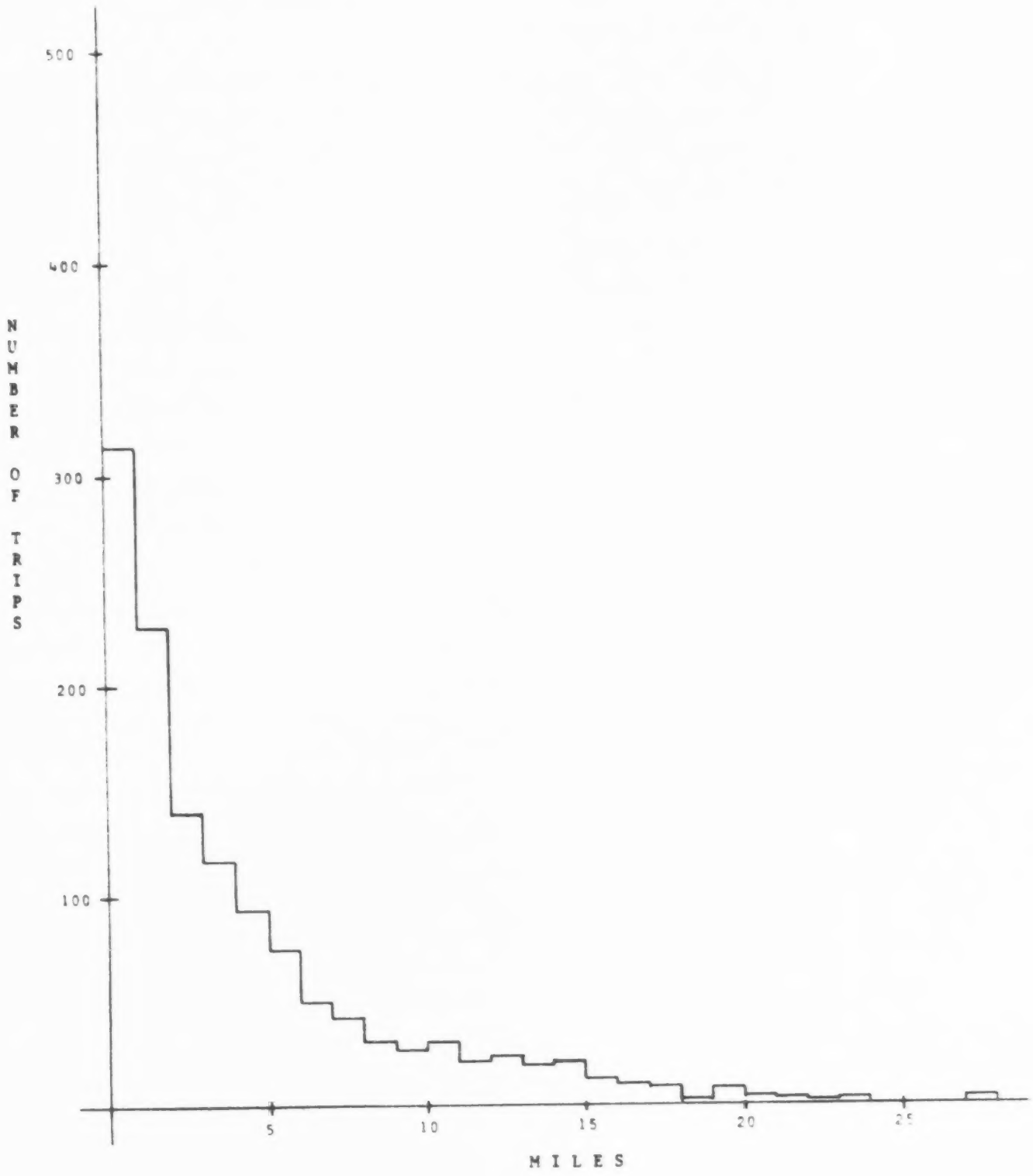


FIGURE 17

DISTRIBUTION OF TRIP DISTANCE, WEEKEND TRIPS

TABLE 16

DISTRIBUTION OF WEEKDAY TRIPS IN CINCINNATI SURVEY BY TRIP SEGMENT STRING SHOWING AVERAGE DISTANCE PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
N: NUMBER OF CASES	51	367	123	207	301	614	494	200	2357
MEAN DISTANCE (MI.)	5.4	7.2	2.5	3.2	5.2	4.5	3.1	4.5	4.5
NFN: NUMBER OF CASES	21	160	21	7	52	159	76	32	528
MEAN DISTANCE	13.3	13.7	11.6	22.8	11.4	13.9	12.3	14.9	13.4
NFNFN: NUMBER OF CASES	3	14	0	1	6	9	4	2	39
MEAN DISTANCE	12.0	18.0	0.0	17.1	27.8	26.0	28.8	52.5	23.7
OTHER: NUMBER OF CASES	0	1	1	2	2	2	1	0	9
MEAN DISTANCE	0.0	13.8	75.2	1.8	13.4	5.4	0.9	0.0	14.6
TOTAL: NUMBER OF CASES	75	542	145	217	361	784	575	234	2933
MEAN DISTANCE	7.8	9.4	4.3	3.8	6.5	6.6	4.5	6.3	6.4

TABLE 17

DISTRIBUTION OF WEEKEND TRIPS IN CINCINNATI SURVEY BY TRIP SEGMENT STRING SHOWING AVERAGE DISTANCE PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
N: NUMBER OF CASES	113	169	196	376	202	76	1132
MEAN DISTANCE (MI.)	4.8	2.8	3.1	3.7	3.5	4.9	3.6
NFN: NUMBER OF CASES	26	18	30	50	27	11	162
MEAN DISTANCE	13.8	13.7	18.8	12.5	11.4	11.4	13.8
NFNFN: NUMBER OF CASES	3	4	3	5	3	1	19
MEAN DISTANCE	26.3	51.3	46.1	22.2	47.6	16.0	36.4
OTHER: NUMBER OF CASES	0	2	0	1	0	0	3
MEAN DISTANCE	0.0	6.4	0.0	46.6	0.0	0.0	19.8
TOTAL: NUMBER OF CASES	142	193	229	432	232	88	1316
MEAN DISTANCE	6.9	4.9	5.7	5.0	5.0	5.8	5.4

TABLE 18

AVERAGE DISTANCE FOR SEGMENTS OF WEEKDAY
FREEWAY TRIPS BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
NONFREEWAY[1]									
NUMBER OF CASES	51	361	47	19	139	338	165	68	1188
AVERAGE DISTANCE	2.9	3.8	3.2	4.0	2.5	4.0	2.9	3.7	3.5
FREEWAY									
NUMBER OF CASES	29	188	23	11	72	173	87	35	618
AVERAGE DISTANCE	5.9	5.7	6.3	10.4	6.5	6.9	6.5	9.1	6.6
TOTAL									
NUMBER OF CASES	80	549	70	30	211	511	252	103	1806
AVERAGE DISTANCE	4.0	4.5	4.2	6.4	3.9	5.0	4.2	5.5	4.6

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

TABLE 19

AVERAGE DISTANCE FOR SEGMENTS OF WEEKEND FREEWAY TRIPS
IN CINCINNATI SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
NONFREEWAY[1]							
NUMBER OF CASES	59	47	68	124	61	25	384
AVERAGE DISTANCE	3.4	3.3	3.1	3.6	3.4	3.6	3.4
FREEWAY							
NUMBER OF CASES	32	25	38	63	33	13	204
AVERAGE DISTANCE	7.3	8.7	14.7	6.3	6.4	4.0	8.2
TOTAL							
NUMBER OF CASES	91	72	106	187	94	38	588
AVERAGE DISTANCE	4.8	5.2	7.3	4.5	4.5	3.7	5.1

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

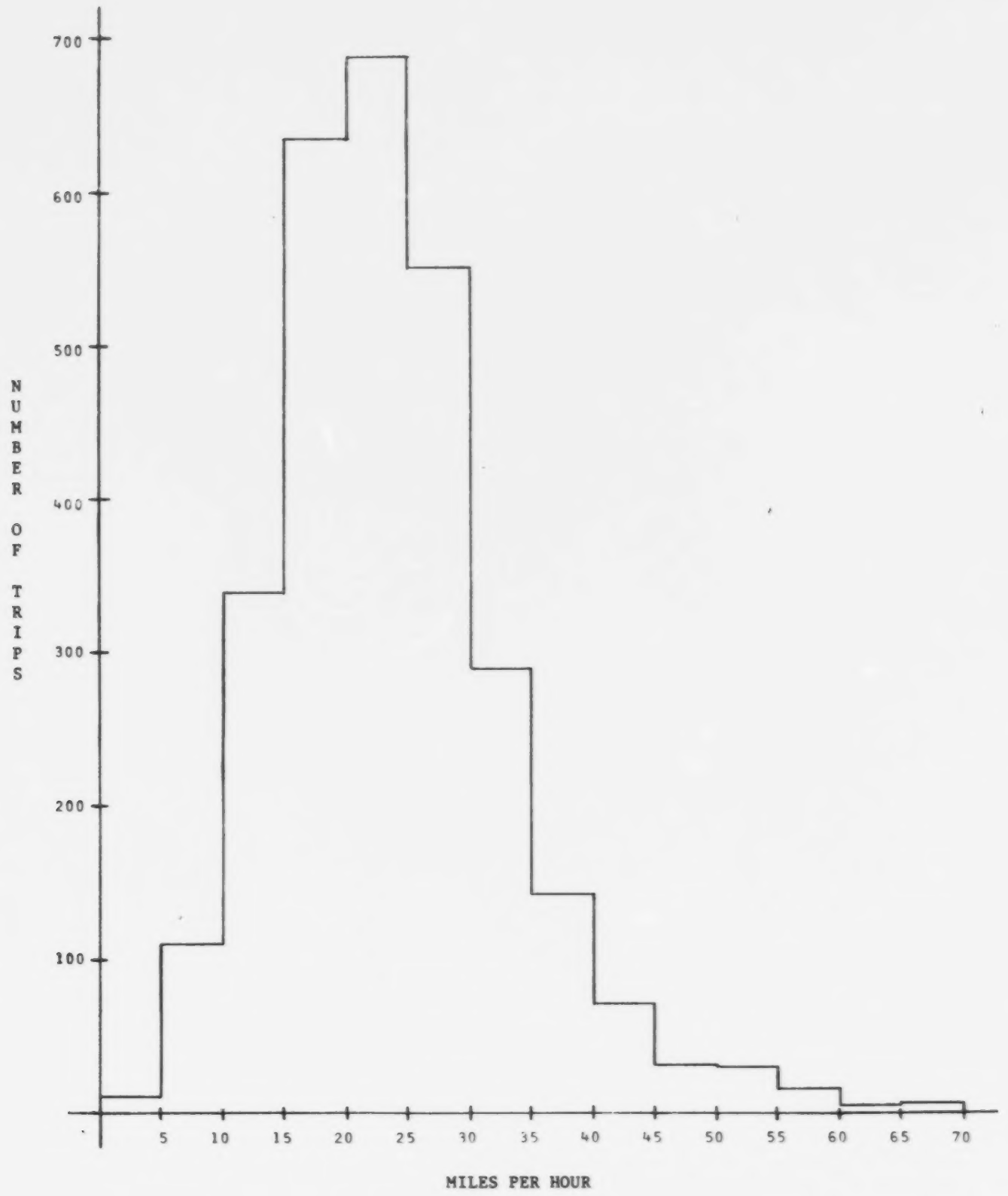


FIGURE 18

DISTRIBUTION OF AVERAGE SPEED, WEEKDAY TRIPS

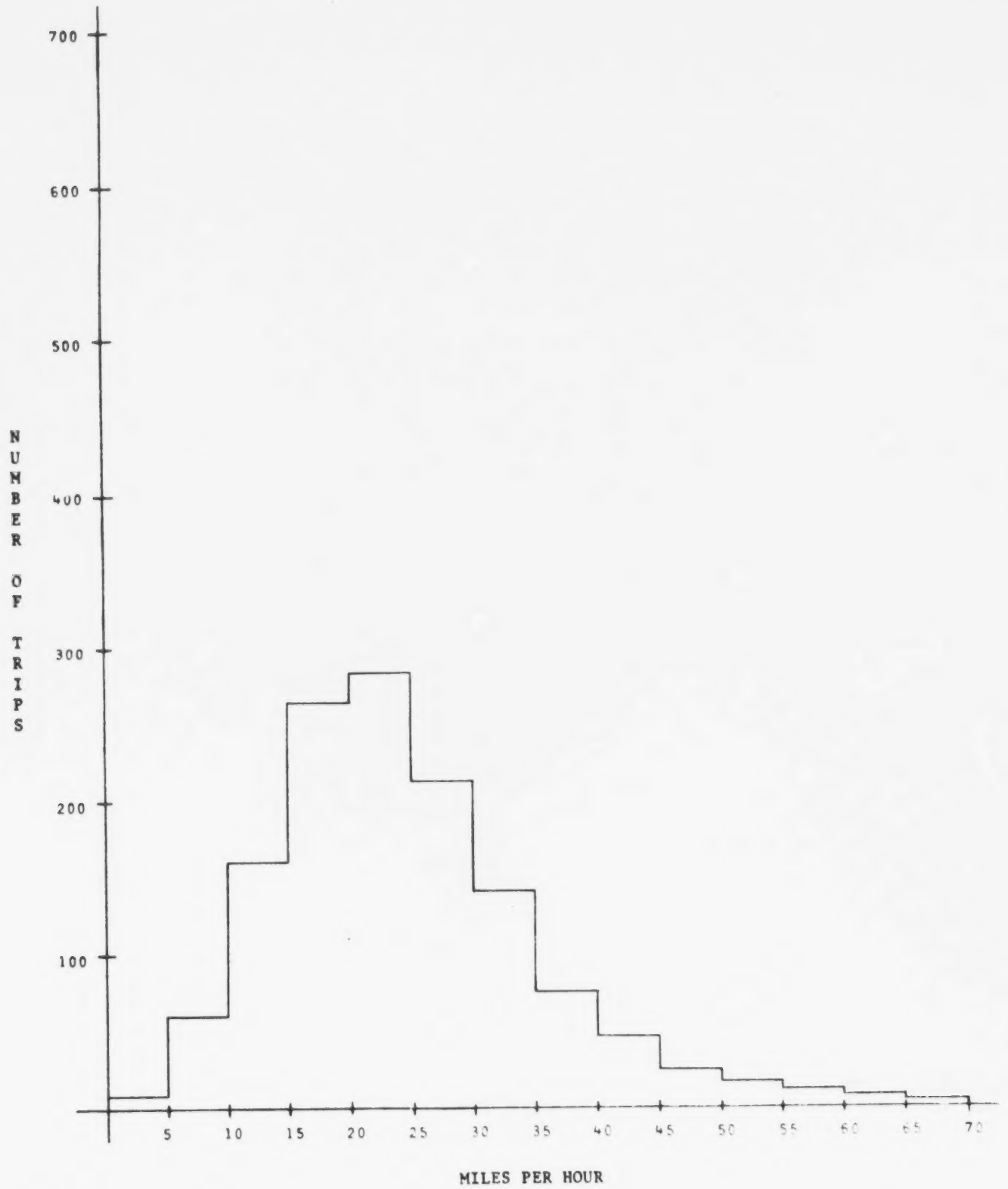


FIGURE 19

DISTRIBUTION OF AVERAGE SPEED, WEEKEND TRIPS

interval for weekday average speed is from 23.5 to 24.2 miles per hour. For weekend average speed the interval is from 24.3 to 25.0 miles per hour. Again, the time and trip segment string distribution points out greater differences. Tables 20 and 21 are analogous to the previous tabular presentation on trip distance. One notices increased average velocities on all freeway-associated trips as compared to the nonfreeway trips, but the degree of increase varies with time slot.

Tables 22 and 23 provide average velocity information on freeway and freeway segments associated with freeway trips by time slot for weekdays and weekends.

Trip and Segment Elapsed Time

The distributions of elapsed time for weekday and weekend trips are shown in Figures 20 and 21 respectively. The mean for weekday trips is 16.3 minutes, for weekend trips it is 12.4 minutes. The weekday distribution indicates that 90% of all trips on these days are completed within 36 minutes. On weekends, this figure drops to 28 minutes.

Tables 24 and 25 show the mean elapsed time by time slot and trip segment string. The dependency of elapsed time on the complexity of the trip segment structure stands out clearly. Tables 26 and 27 present mean segment elapsed time for trips involving the use of freeways on weekdays and weekend days. The large number of short trip times is obviously related to the similar prevalence of short trip distances discussed previously.

Trip and Segment Idling

The present survey measures idling time in terms of two parameters: the number of stops with engine running per trip or segment and the actual idling time accumulated during periods of idling in excess of about 40 seconds. The mean number of stops per trip by time slot and trip segment string is shown in Tables 28 and 29 for weekday and weekend trips. Tables 30 and 31 show the mean number of stops for trip segments of freeway trips on weekdays and weekends.

TABLE 20

DISTRIBUTION OF WEEKDAY TRIPS IN CINCINNATI SURVEY BY TRIP

SEGMENT STRING SHOWING AVERAGE SPEED IN MILES PER HOUR PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
N: NUMBER OF CASES	51	367	123	207	301	614	494	200	2357
AVERAGE SPEED (MPH)	22.8	20.5	22.5	22.4	21.3	22.8	24.6	21.6	22.5
NFN: NUMBER OF CASES	21	160	21	7	52	159	76	32	528
AVERAGE SPEED	30.9	27.9	29.1	37.5	29.9	29.0	31.0	31.3	29.4
NFNFN: NUMBER OF CASES	3	14	0	1	6	9	4	2	39
AVERAGE SPEED	29.6	30.7	0.0	23.8	36.3	32.1	29.8	37.9	31.9
OTHER: NUMBER OF CASES	0	1	1	2	2	2	1	0	9
AVERAGE SPEED	0.0	24.3	51.5	35.2	26.4	17.6	15.4	0.0	27.7
TOTAL: NUMBER OF CASES	75	542	145	217	361	784	575	234	2933
AVERAGE SPEED	25.3	23.0	23.7	23.1	22.8	24.2	25.4	23.1	23.9

TABLE 21

DISTRIBUTION OF WEEKEND TRIPS IN CINCINNATI SURVEY BY TRIP

SEGMENT STRING SHOWING AVERAGE SPEED IN MILES PER HOUR PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1330-1759	1800-2059	2100-2359	
N: NUMBER OF CASES	113	169	196	376	202	76	1132
AVERAGE SPEED (MPH)	24.1	23.7	23.9	22.5	24.8	21.1	23.4
NFN: NUMBER OF CASES	26	18	30	50	27	11	162
AVERAGE SPEED	33.7	33.0	36.2	31.2	31.8	28.4	32.6
NFNFN: NUMBER OF CASES	3	4	3	5	3	1	19
AVERAGE SPEED	31.5	39.1	45.1	29.3	29.4	20.6	33.8
OTHER: NUMBER OF CASES	0	2	0	1	0	0	3
AVERAGE SPEED	0.0	32.3	0.0	39.8	0.0	0.0	34.8
TOTAL: NUMBER OF CASES	142	193	229	432	232	88	1316
AVERAGE SPEED	26.0	25.0	25.8	23.6	25.6	22.0	24.7

TABLE 22

AVERAGE SPEED FOR SEGMENTS OF WEEKDAY FREEWAY
TRIPS IN CINCINNATI SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
NONFREEWAY[1]									
NUMBER OF CASES	51	361	47	19	139	338	165	68	1188
AVERAGE SPEED	28.0	24.7	27.4	30.8	26.6	27.4	28.2	26.5	26.6
FREEWAY									
NUMBER OF CASES	29	188	23	11	71	173	87	35	618
AVERAGE SPEED	38.8	33.7	36.0	39.5	35.7	34.9	37.4	35.6	35.3
TOTAL									
NUMBER OF CASES	80	549	70	30	211	511	252	103	1806
AVERAGE SPEED	32.0	27.8	30.2	34.0	29.7	30.0	31.4	29.6	29.6

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIP WITH N-TRIP SEGMENT SEQUENCE)

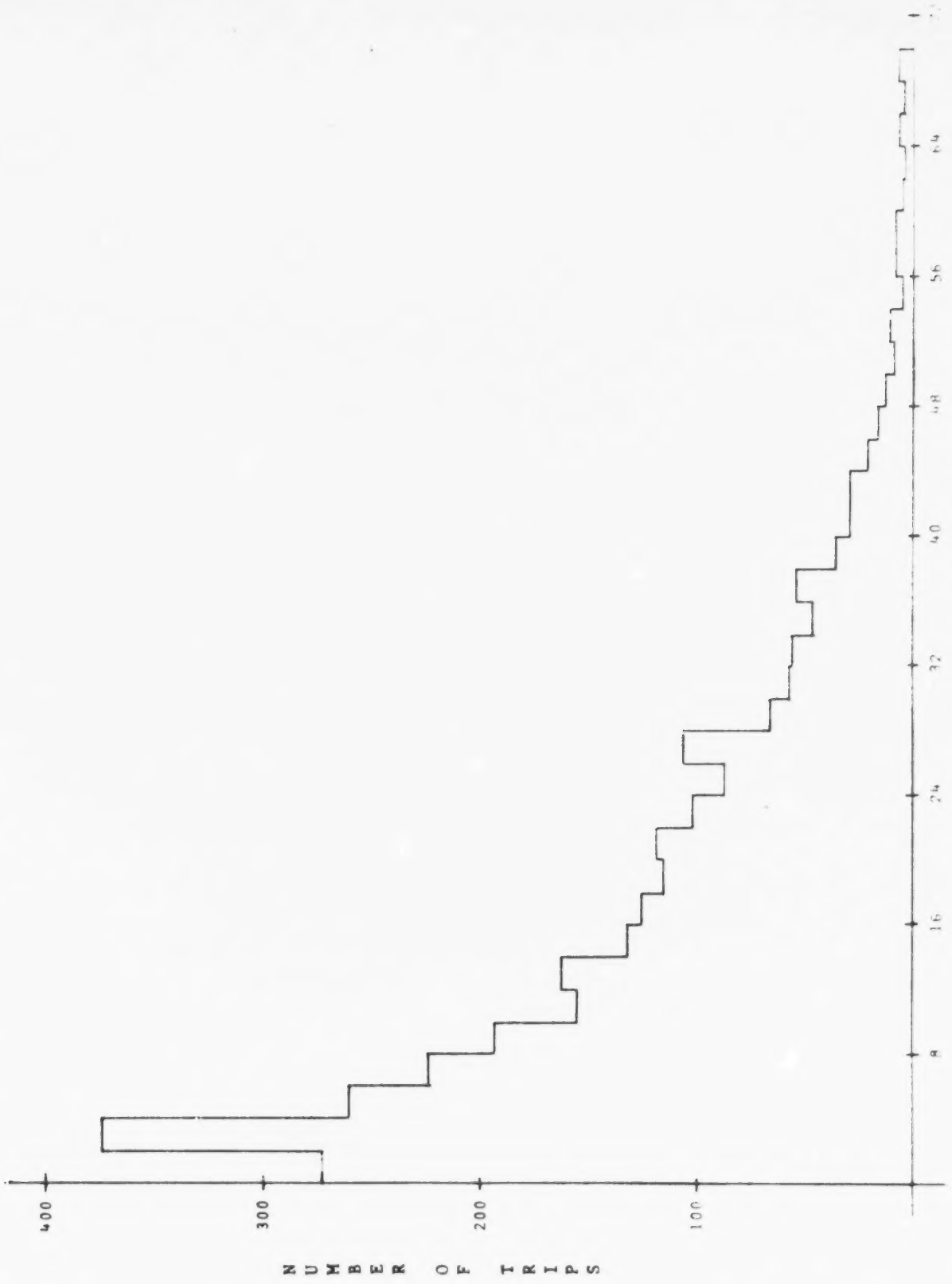


FIGURE 20

DISTRIBUTION OF TRIP TIME, WEEKDAY TRIPS

TABLE 23

AVERAGE SPEEDS FOR SEGMENTS OF WEEKEND FREEWAY
TRIPS IN CINCINNATI SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
NONFREEWAY[1]							
NUMBER OF CASES	59	47	68	124	61	25	384
AVERAGE SPEED	28.3	26.9	34.0	30.9	30.0	25.6	30.1
FREEWAY							
NUMBER OF CASES	32	25	38	63	33	13	204
AVERAGE SPEED	36.1	43.4	46.6	35.9	34.8	32.9	38.5
TOTAL							
NUMBER OF CASES	91	72	106	187	94	38	588
AVERAGE SPEED	31.0	32.6	38.5	32.6	31.7	28.1	33.0

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

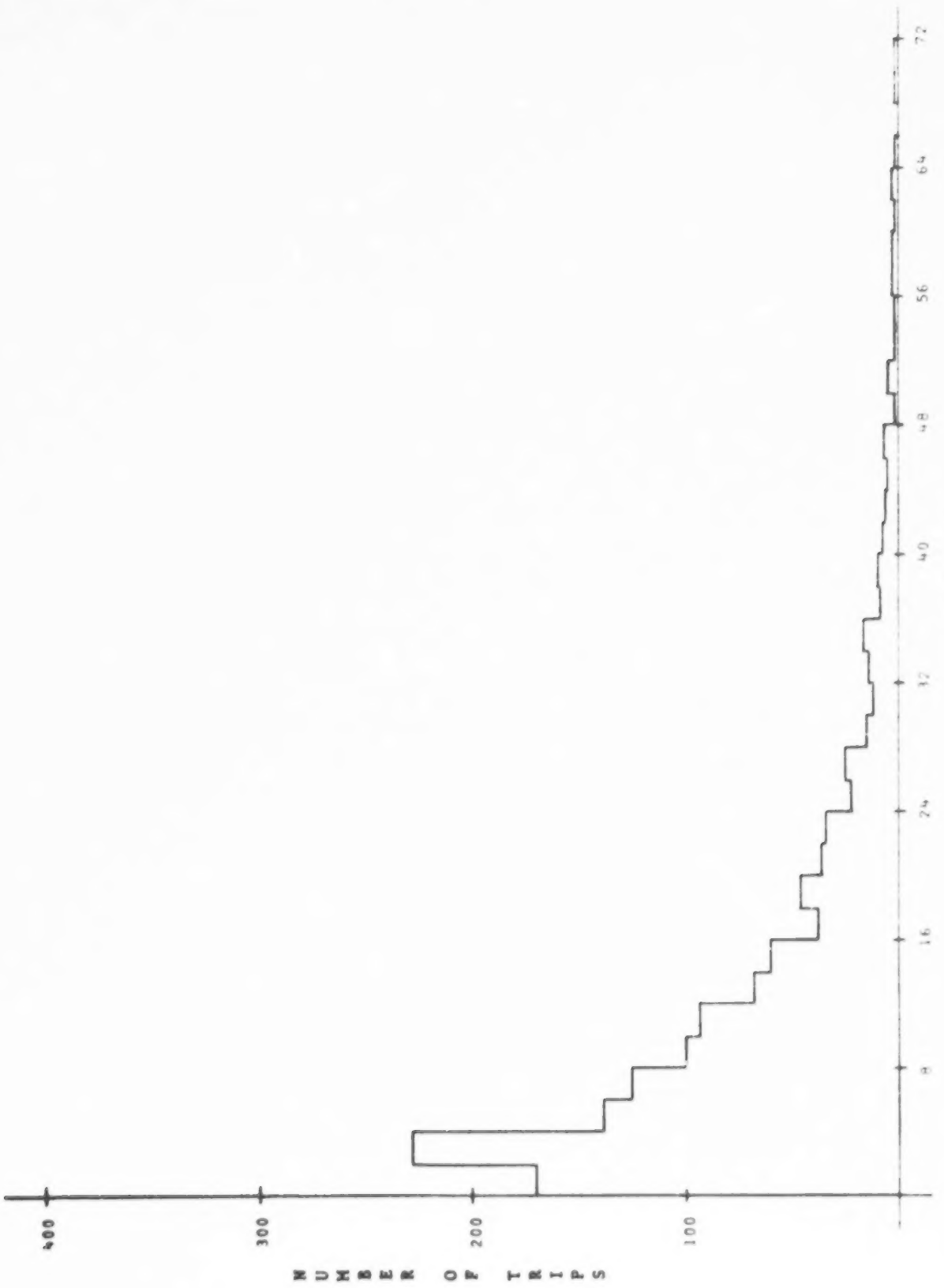


FIGURE 21

DISTRIBUTION OF TRIP TIME, WEEKEND TRIPS

TABLE 24

DISTRIBUTION OF WEEKDAY TRIPS IN THE CINCINNATI SURVEY BY TRIP SEGMENT STRING SHOWING AVERAGE TRIP ELAPSED TIME IN MINUTES PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
N: NUMBER OF CASES	51	367	123	207	301	614	494	200	2357
ELAPSED TIME (MIN)	14.0	21.4	7.2	8.9	14.7	12.7	8.3	13.0	12.8
NFN: NUMBER OF CASES	21	160	21	7	52	159	76	32	528
ELAPSED TIME	27.8	29.8	25.1	31.6	22.0	29.9	23.7	28.6	27.8
NFNFN: NUMBER OF CASES	3	14	0	1	6	9	4	2	39
ELAPSED TIME	24.3	25.6	0.0	43.2	41.0	48.1	50.1	75.9	38.6
OTHER: NUMBER OF CASES	0	1	1	2	2	2	1	0	9
ELAPSED TIME	0.0	34.0	75.2	3.8	31.9	17.3	3.6	0.0	24.3
TOTAL: NUMBER OF CASES	75	542	145	217	361	784	575	234	2933
ELAPSED TIME	18.3	24.0	10.3	9.8	16.3	16.6	10.6	15.6	15.9

TABLE 25

DISTRIBUTION OF WEEKEND TRIPS IN THE CINCINNATI SURVEY BY TRIP SEGMENT STRING SHOWING AVERAGE TRIP ELAPSED TIME IN MINUTES PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
N: NUMBER OF CASES	113	169	196	376	202	76	1132
ELAPSED TIME (MIN)	12.1	7.7	8.1	10.2	9.3	13.6	9.7
NFN: NUMBER OF CASES	26	18	30	50	27	11	162
ELAPSED TIME	26.0	23.5	28.6	25.0	22.6	24.7	25.2
NFNFN: NUMBER OF CASES	3	4	3	5	3	1	19
ELAPSED TIME	46.6	67.6	64.0	47.0	88.9	46.5	60.5
OTHER: NUMBER OF CASES	0	2	0	1	0	0	3
ELAPSED TIME	0.0	11.8	0.0	70.2	0.0	0.0	31.2
TOTAL: NUMBER OF CASES	142	193	229	432	232	88	1316
ELAPSED TIME	15.4	10.5	11.5	12.4	11.9	15.4	12.4

TABLE 26

AVERAGE ELAPSED TIME IN MINUTES FOR SEGMENTS OF WEEKDAY FREEWAY TRIPS IN CINCINNATI SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2050	2100-2359	
NONFREEWAY[1]									
NUMBER OF CASES	51	361	47	19	139	338	165	68	1188
ELAPSED TIME	7.1	9.5	7.8	7.9	5.9	10.0	6.8	9.4	8.7
FREEWAY									
NUMBER OF CASES	29	188	23	11	72	173	87	35	618
ELAPSED TIME	9.9	9.8	10.4	12.8	10.0	10.5	10.3	14.0	10.4
TOTAL									
NUMBER OF CASES	80	549	70	30	211	511	252	103	1806
ELAPSED TIME	8.1	9.6	8.6	9.7	7.3	10.2	8.0	11.0	9.2

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS (I.E., TRIPS WITH N-TRIP SEGMENT SEQUENCE)

TABLE 27

AVERAGE ELAPSED TIME IN MINUTES FOR SEGMENTS OF
WEEKEND FREEWAY TRIPS IN CINCINNATI SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
NONFREEWAY[1]							
NUMBER OF CASES	59	47	68	124	61	25	384
ELAPSED TIME	7.5	7.4	6.7	7.7	7.8	8.8	7.5
FREEWAY							
NUMBER OF CASES	32	25	38	63	33	13	204
ELAPSED TIME	11.6	11.0	17.1	10.8	10.5	7.5	11.9
TOTAL							
NUMBER OF CASES	91	72	106	187	94	38	588
ELAPSED TIME	8.9	8.6	10.4	8.7	8.8	8.4	9.0

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

TABLE 28

DISTRIBUTION OF WEEKDAY TRIPS IN CINCINNATI SURVEY BY TRIP SEGMENT STRING SHOWING AVERAGE NUMBER OF TRIP STOPS WITH ENGINE ON PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2350	
N: NUMBER OF CASES	51	367	123	207	301	614	494	200	2357
NUMBER OF STOPS (ENGINE ON)	4.0	8.7	3.4	3.9	6.5	6.3	3.3	4.3	5.5
NFN: NUMBER OF CASES	21	160	21	7	52	159	76	32	528
NUMBER OF STOPS	7.0	8.6	8.1	4.4	5.7	9.4	6.3	6.2	8.0
NFNFN: NUMBER OF CASES	3	14	0	1	6	9	4	2	39
NUMBER OF STOPS	2.7	10.2	0.0	17.0	5.3	10.0	7.5	8.5	8.6
OTHER: NUMBER OF CASES	0	1	1	2	2	2	1	0	9
NUMBER OF STOPS	0.0	13.0	4.0	2.0	16.0	5.5	9.0	0.0	8.1
TOTAL: NUMBER OF CASES	75	542	145	217	361	784	575	234	2933
NUMBER OF STOPS	4.8	8.7	4.1	4.0	6.4	6.9	3.7	4.6	6.0

TABLE 29

DISTRIBUTION OF WEEKEND TRIPS IN CINCINNATI SURVEY BY TRIP SEGMENT STRING SHOWING AVERAGE NUMBER OF TRIP STOPS WITH ENGINE ON PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
N: NUMBER OF CASES	113	169	196	376	202	76	1132
NUMBER OF STOPS (ENGINE ON)	3.6	3.2	3.6	4.0	3.8	4.0	3.7
NFN: NUMBER OF CASES	26	18	30	50	27	11	162
NUMBER OF STOPS	5.3	5.8	5.7	6.8	6.3	6.7	6.2
NFNFN: NUMBER OF CASES	3	4	3	5	3	1	19
NUMBER OF STOPS	7.0	8.8	11.7	9.4	15.0	13.0	10.3
OTHER: NUMBER OF CASES	0	2	0	1	0	0	3
NUMBER OF STOPS	0.0	3.0	0.0	9.0	0.0	0.0	5.0
TOTAL: NUMBER OF CASES	142	193	229	432	232	88	1316
NUMBER OF STOPS	4.0	3.6	4.0	4.4	4.5	4.5	4.1

TABLE 30

AVERAGE NUMBER OF ENGINE-ON STOPS FOR SEGMENTS OF WEEKDAY FREEWAY TRIPS IN CINCINNATI SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
NONFREEWAY[1]									
NUMBER OF CASES	51	361	47	19	139	338	165	68	1188
NUMBER OF STOPS	2.1	4.1	3.8	2.8	2.6	4.2	2.8	3.0	3.6
FREEWAY									
NUMBER OF CASES	29	188	23	11	72	173	87	35	618
NUMBER OF STOPS	0.6	0.4	0.2	0.4	0.9	0.7	0.6	0.2	0.6
TOTAL									
NUMBER OF CASES	80	549	70	30	211	511	252	103	1806
NUMBER OF STOPS	1.6	2.8	2.6	2.0	2.0	3.0	2.0	2.1	2.6

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS (I E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

TABLE 31

AVERAGE NUMBER OF ENGINE-ON STOPS FOR SEGMENTS OF WEEKEND FREEWAY TRIPS IN CINCINNATI SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
NONFREEWAY[1]							
NUMBER OF CASES	59	47	68	124	61	25	384
NUMBER OF STOPS	2.5	2.8	3.0	3.0	3.3	3.4	3.0
FREEWAY							
NUMBER OF CASES	32	25	38	63	33	13	204
NUMBER OF STOPS	0.1	0.6	0.2	0.5	0.3	0.1	0.4
TOTAL							
NUMBER OF CASES	91	72	106	187	94	38	588
NUMBER OF STOPS	1.7	2.0	2.0	2.2	2.2	2.3	2.1

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS (I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

Tables 32 and 33 show mean measured idling time for weekday and weekend trips while Tables 34 and 35 show similar data for segments of freeway trips.

Most trips in the Cincinnati survey showed zero measured idling time. Over 90% of all trips had less than a minute (90.5% for weekdays and 93.6% for weekends). Nevertheless, there were cases of idling periods of considerable length, no doubt largely due to warm-up periods at the beginning of trips due to the cold weather. Almost 2% of the weekday trips and 1% of the weekend trips showed idle time in excess of 10 minutes! As a result, the mean idling period for weekday trips turned out to be 0.6 minute and for weekend trips 0.4 minute.

Elapsed Time Between Trips

Figures 22 and 23 show the distribution of elapsed time between trips for weekday and weekend. The time scale on each figure is broken in several places: at one hour, to enable a more precise breakdown of shorter intertrip times; and at daily intervals from two to six days to enable the agglomeration of larger intertrip times. Tables 36 and 37 show the breakdown of elapsed time from last trip by time slot and purpose of trip for weekday and weekend trips. Since this quantity is not associated with the trip segment structure but is quite clearly associated with trip purpose, we believe this breakdown is more reasonable than that based upon the time slot/trip segment string criterion used previously.

In addition to this quantity, the survey results also contain data on the incidence of engine-off stops of less than five minutes. This quantity does not show up as an elapsed time between trips since if such a stop occurred, the computer program merged the two trips into a single record. The incidence of such stops was very meager. Table 38 shows the results for weekdays and weekend trips.

TABLE 32

DISTRIBUTION OF WEEKDAY TRIPS IN CINCINNATI SURVEY BY TRIP SEGMENT STRING SHOWING AVERAGE MEASURED IDLING TIME IN MINUTES PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
N: NUMBER OF CASES	51	367	123	207	301	614	494	200	2357
AVERAGE IDLING TIME	0.4	1.2	0.3	0.3	0.3	0.5	0.4	1.1	0.6
NFN: NUMBER OF CASES	21	160	21	7	52	149	76	32	528
AVERAGE IDLING TIME	2.4	0.6	1.0	0.0	0.2	1.2	0.3	0.0	0.8
NFNFN: NUMBER OF CASES	3	14	0	1	6	9	4	2	39
AVERAGE IDLING TIME	0.0	0.0	0.0	0.0	1.0	0.0	1.6	0.0	0.3
OTHER: NUMBER OF CASES	0	1	1	2	2	2	1	0	9
AVEPAGE IDLING TIME	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.3
TOTAL: NUMBER OF CASES	75	542	145	217	361	784	575	234	2933
AVERAGE IDLING TIME	0.9	1.0	0.4	0.3	0.3	0.6	0.4	0.9	0.6

TABLE 33

DISTRIBUTION OF WEEKEND TRIPS IN CINCINNATI SURVEY BY TRIP SEGMENT STRING SHOWING AVERAGE MEASURED IDLING TIME IN MINUTES PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
N: NUMBER OF CASES	113	169	196	376	202	76	1132
AVERAGE IDLING TIME	0.6	0.4	0.3	0.3	0.2	0.7	0.3
NFN: NUMBER OF CASES	26	18	30	50	27	11	162
AVERAGE IDLING TIME	0.4	0.8	0.1	0.7	0.5	0.5	0.5
NFNFN: NUMBER OF CASES	3	4	3	5	3	1	19
AVERAGE IDLING TIME	0.0	0.5	0.0	0.0	0.0	0.0	0.1
OTHER: NUMBER OF CASES	0	2	0	1	0	0	3
AVERAGE IDLING TIME	0.0	0.0	0.0	4.0	0.0	0.0	1.3
TOTAL: NUMBER OF CASES	142	193	229	432	232	88	1316
AVERAGE IDLING TIME	0.6	0.4	0.2	0.3	0.2	0.7	0.4

TABLE 34

AVERAGE MEASURED IDLING TIME IN MINUTES FOR SEGMENTS
OF WEEKDAY FREEWAY TRIPS IN CINCINNATI BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
NONFREEWAY[1]									
NUMBER OF CASES	51	361	47	19	139	338	165	68	1188
AVG IDLING TIME	1.0	0.2	0.5	0.0	0.1	0.5	0.1	0.0	0.3
FREEWAY									
NUMBER OF CASES	29	188	23	11	72	173	87	35	618
AVG IDLING TIME	0.1	0.1	0.0	0.0	0.0	0.2	0.1	0.0	0.1
TOTAL									
NUMBER OF CASES	80	549	70	30	211	511	252	103	1806
AVG IDLING TIME	0.7	0.2	0.3	0.0	0.1	0.4	0.1	0.0	0.2

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

TABLE 35

AVERAGE MEASURED IDLING TIME IN MINUTES FOR SEGMENTS
OF WEEKEND FREEWAY TRIPS IN CINCINNATI BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
NONFREEWAY[1]							
NUMBER OF CASES	59	47	68	124	61	25	384
AVG IDLING TIME	0.2	0.3	0.1	0.6	0.2	0.2	0.3
FREEWAY							
NUMBER OF CASES	32	25	38	63	33	13	204
AVG IDLING TIME	0.0	0.1	0.0	0.0	0.1	0.0	0.0
TOTAL							
NUMBER OF CASES	91	72	106	187	94	38	588
AVG IDLING TIME	0.1	0.2	0.0	0.4	0.1	0.2	0.2

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

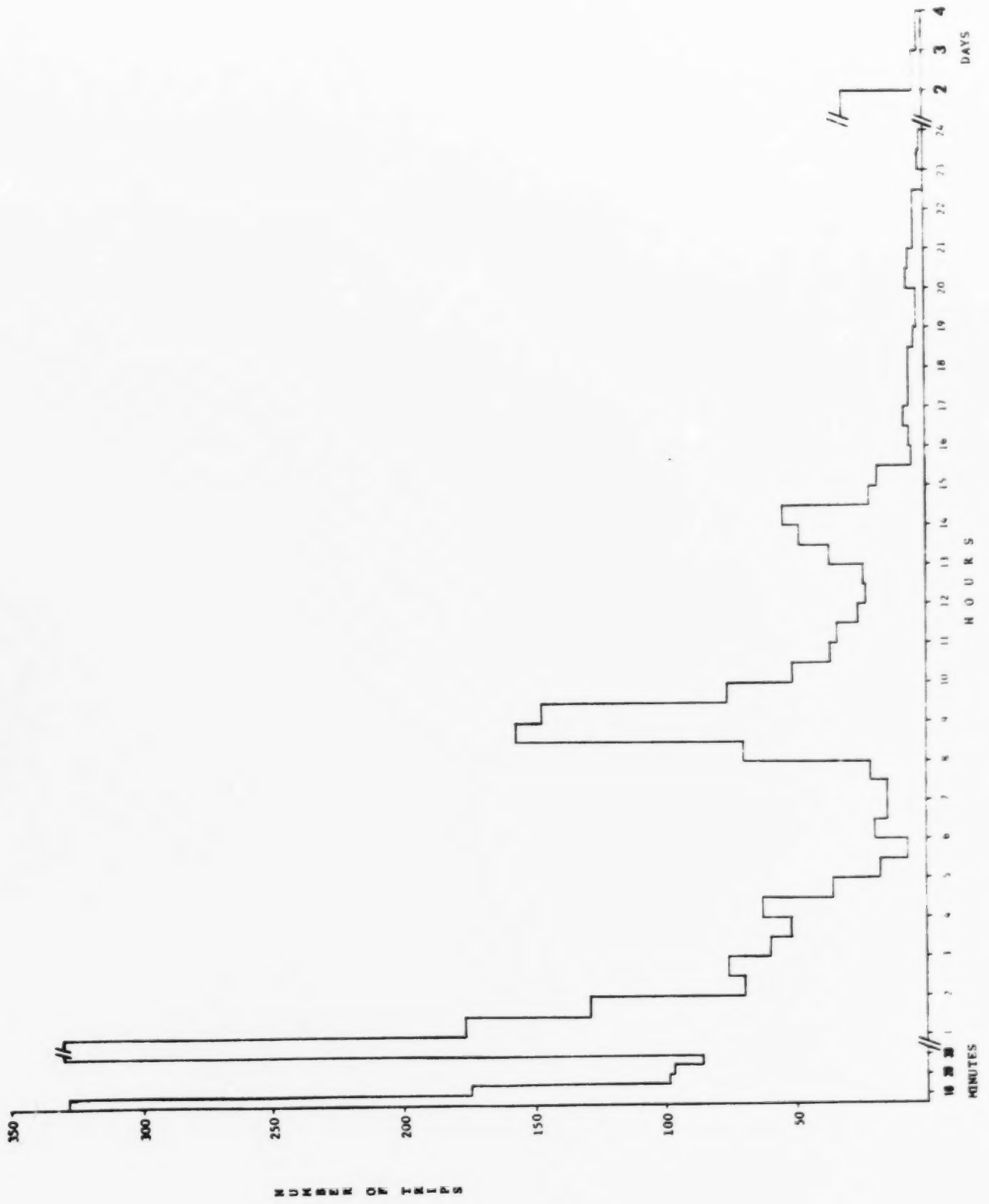


FIGURE 22

DISTRIBUTION OF ELAPSED TIME BETWEEN TRIPS, WEEKDAY

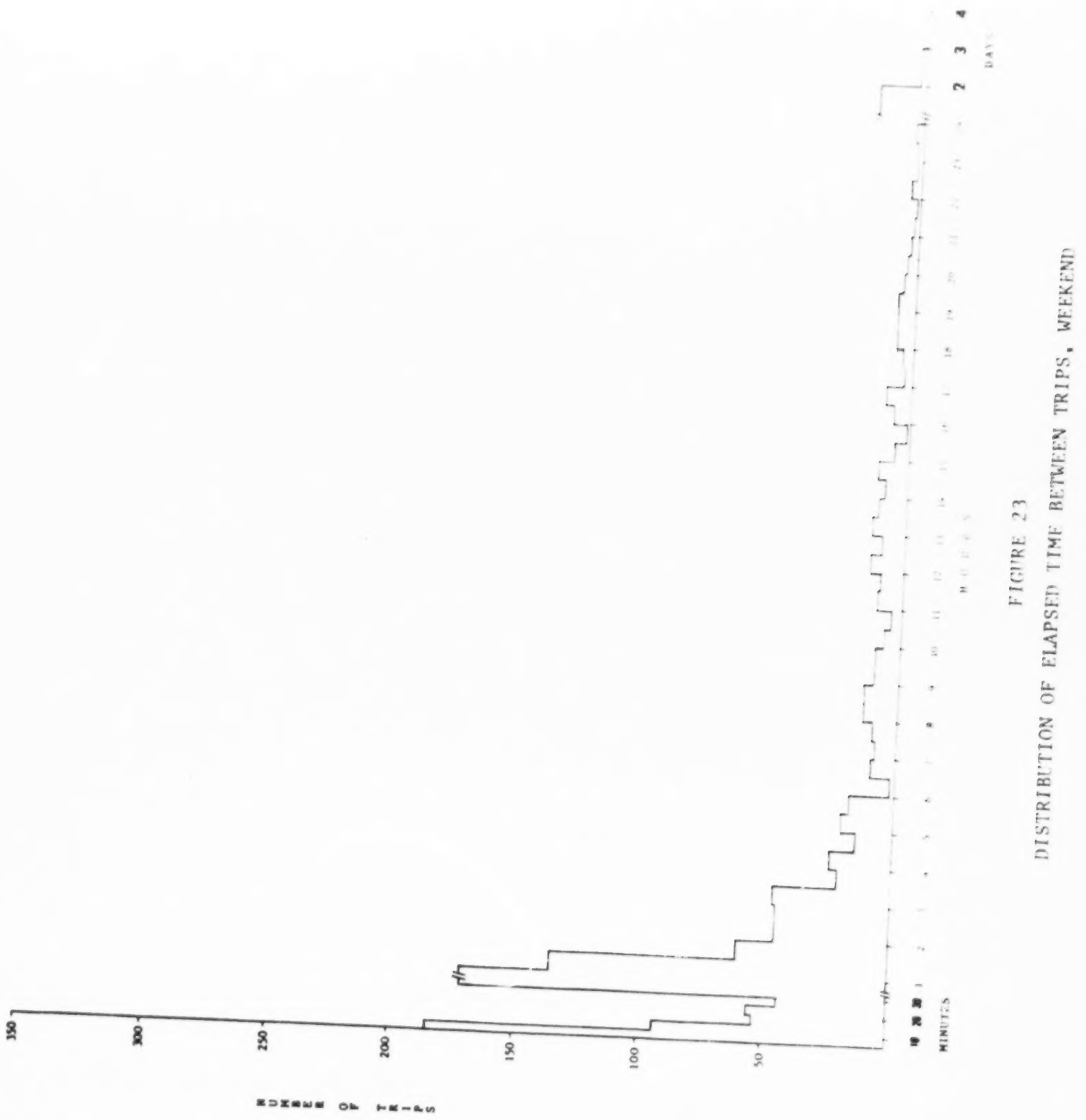


FIGURE 23
DISTRIBUTION OF ELAPSED TIME BETWEEN TRIPS, WEEKEND

TABLE 36

AVERAGE ELAPSED TIME SINCE LAST TRIP FOR WEEKDAY
TRIPS IN CINCINNATI SURVEY BY TIME SLOT AND PURPOSE

PURPOSE OF TRIP	TIME SLOT							TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
GO HOME	33 4:24	9 6:31	28 2:06	42 1:37	147 5:28	430 5:05	229 1:27	151 2:15	1069 2:10
GO TO WORK	28 14:06	471 12:49	32 5:23	60 1:49	39 4:13	28 4:39	2 6:24	2 1:29	662 10:12
BUSINESS	5 3:55	24 6:11	28 1:50	17 2:49	28 5:59	41 6:26	25 2:35	8 2:35	176 4:23
SHOPPING	5 3:46	28 11:04	42 6:03	85 4:24	107 4:11	202 4:36	181 2:18	19 3:27	669 4:06
CHURCH, SCHOOL, ETC.	0 –	5 12:30	5 14:49	4 5:22	8 4:49	24 6:15	24 3:08	1 2:51	71 5:59
RECREATION	4 0:38	5 7:38	10 5:14	9 4:16	32 4:47	59 2:42	114 1:50	53 1:28	286 2:34
TOTAL	75 7:38	542 9:55	145 4:36	217 2:52	361 4:55	784 4:52	575 1:57	234 2:10	2933 6:33

TABLE 37

AVERAGE ELAPSED TIME SINCE LAST TRIP FOR WEEKEND
TRIPS IN CINCINNATI SURVEY BY TIME SLOT AND PURPOSE

PURPOS PURPOSE OF TRIP	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
GO HOME	53 3:04	48 0:48	76 0:59	163 1:51	87 2:39	53 2:43	480 1:59
GO TO WORK	28 9:57	11 9:42	6 2:13	13 2:40	2 1:01	1 2:59	61 7:11
BUSINESS	12 5:26	12 5:31	10 1:16	18 2:56	7 2:58	2 22:06	61 4:18
SHOPPING	26 6:15	63 7:22	90 4:39	161 4:56	45 3:41	7 3:57	392 5:11
CHURCH, SCHOOL, ETC.	7 8:33	35 13:34	18 10:10	9 2:3[illegible]	5 6:09	0 –	74 10:26
RECREATION	16 2:57	24 6:24	29 5:10	68 4:08	86 3:24	25 1:56	248 3:55
TOTAL	142 5:28	193 6:45	229 3:43	432 3:26	232 3:12	88 3:02	1316 4:07

TABLE 38

NUMBER OF CASES OF ENGINE-OFF STOPS
FOR WEEKDAY AND WEEKEND TRIPS IN CINCINNATI SURVEY

NUMBER OF STOPS	NUMBER OF TRIPS	
	WEEKDAY	WEEKEND
0	2755 (94%)	1211 (92%)
1	173 (6%)	105 (8%)

Parking

The results obtained on parking habits during the survey indicate a high likelihood that most residents in the Cincinnati area leave their cars outdoors both at night and between trips. The percentage of indoor parkers is, however, higher than in previously studied cities. Table 39 shows the results for weekdays and weekends. Survey participants were told that only closed garages constituted indoor parking.

TABLE 39

INDOOR AND OUTDOOR PARKING OVERNIGHT AND BETWEEN
TRIPS FOR WEEKDAYS AND WEEKEND DAYS IN CINCINNATI SURVEY

	INDOOR	OUTDOOR
WEEKDAYS:		
BETWEEN TRIPS	316 (10.8%)	2617 (89.2%)
OVERNIGHT	231 (34.0%)	449 (66.0%)
WEEKEND DAYS:		
BETWEEN TRIPS	129 (9.8%)	1187 (90.2%)
OVERNIGHT	78 (28.7%)	194 (71.3%)

Overnight Fuel Tank Readings

Table 40 shows the percentage of fuel tank readings at the empty, one-quarter, one-half, three-quarter, and full levels for weekdays and weekend days. Survey participants were asked to note the reading at the start of the day's travel.

TABLE 40

OVERNIGHT FUEL TANK READINGS FOR WEEKDAYS AND WEEKEND DAYS IN CINCINNATI SURVEY (EXPRESSED AS A PERCENTAGE OF CAR-DAYS FOR THE TWO CATEGORIES)

READING	PERCENTAGE OF CAR-DAYS	
	WEEKDAY	WEEKEND
EMPTY	4.5%	5.9%
1/4	25.2%	26.9%
1/2	30.3%	26.5%
3/4	22.4%	16.9%
FULL	17.5%	23.7%

Use of Freeways Versus Surface Streets

Approximately 80% of all weekday trips and 86% of all weekend trips in the Cincinnati survey were made entirely on surface streets. The previous tables showing the breakdown of trip descriptor variables by trip segment string indicate that the freeway trip is both longer and carried out at a greater average speed than the nonfreeway trip. The freeway system in Cincinnati is incomplete. Interstate 75 crosses the Ohio River from Kentucky slightly west of the downtown area and proceeds north dividing the metropolitan area in half. U.S. 50, which parallels the Ohio River, is a divided limited access road through the downtown area. Interstate 275, only partially complete, will provide a diversionary route around the north and east of the city. Only a portion of the northern route, on either side of its intersection with Interstate 75, was open at the time of the survey. Finally, several other freeway segments which will ultimately enter the city from the northwest and northeast were available for use over short stretches in the suburban area but were not complete. This lack of freeways, no doubt, is one of the primary reasons for the high percentage of nonfreeway trips, higher than in either of the previous cities.

As in the previous two studies, Figures 24 through 31 were prepared to assist in determining whether the driver tends to use a freeway because of the greater distance he must cover or because of the speed advantage he may obtain. The figures show the distribution of trip distance for nonfreeway and freeway trips by three-mile increments within each of the eight weekday time slots. While all of the charts are not entirely similar, they continue in general to show the trend established in Los Angeles and Houston. Basically all, with the major exception of time slot two (Figure 25), show an exponentially-shaped frequency function for the combination of all trips, nonfreeway and freeway. The frequency distribution function for freeways tends, however, to be bell-shaped, indicating that the freeway driver tends to select his route because of the distance he must travel. It would appear that the anomaly in time slot

two, where there is a high proportion of nonfreeway trips greater than three miles, is conditioned heavily by the lack of freeway routes between origin and destination during the morning rush hour.

During the Cincinnati survey, 11,000 miles out of the total 26,000 miles driven by survey participants (42%) were on trips that involved freeway segments and 5700 of these were actual freeway miles. The 42% represents a significant decrease from both the Los Angeles and Houston values, 68% and 56% respectively.

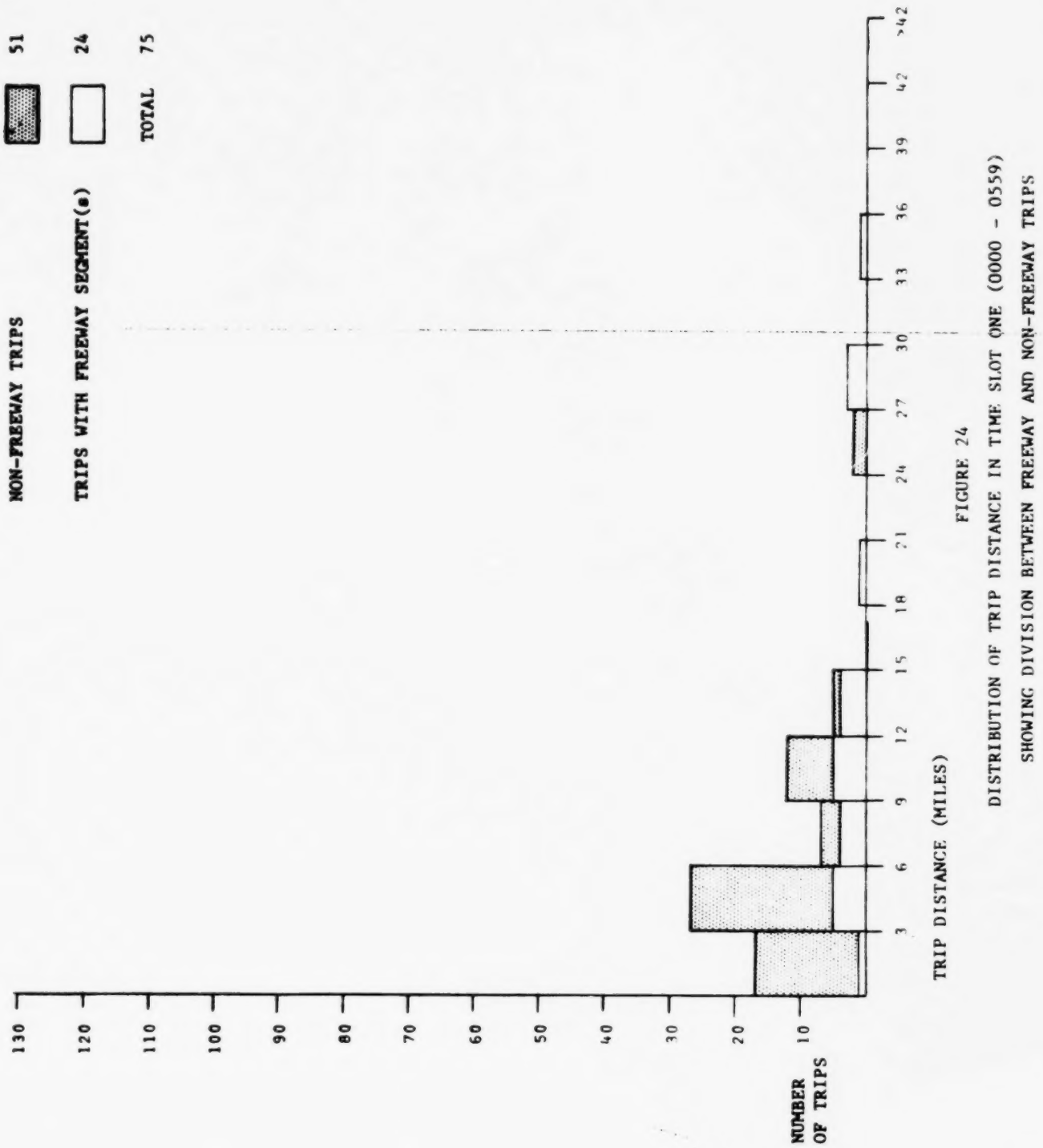
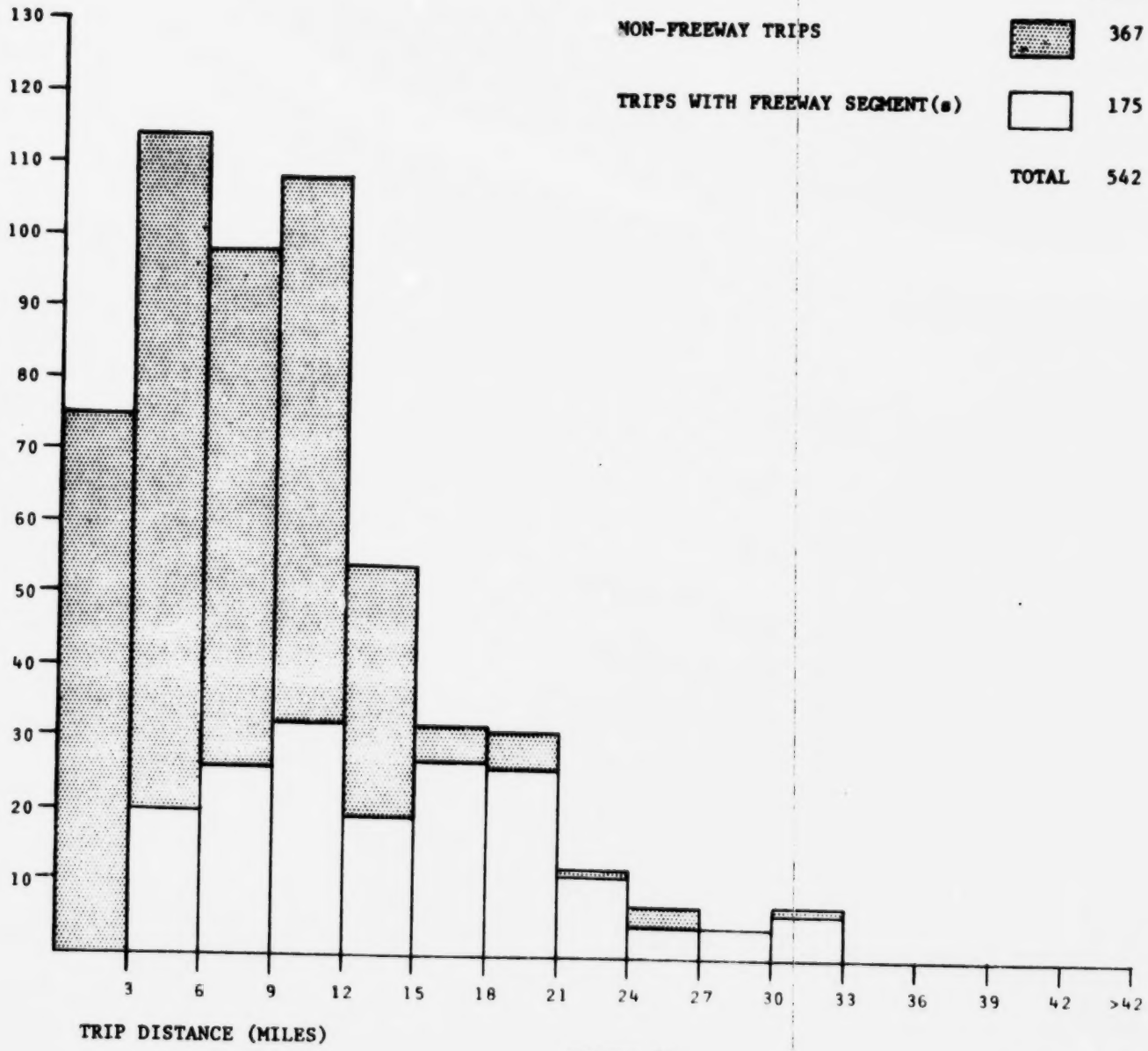

NUMBER PERCENT
NON-FREEWAY TRIPS 51 68.0%
TRIPS WITH FREEWAY SEGMENT(s) 24 32.0%
TOTAL 75
NUMBER OF TRIPS
TRIP DISTANCE (MILES)
3 6 9 12 15 18 21 24 27 30 33 36 39 42 >42
10 20 30 40 50 60 70 80 90 100 110 120 130

FIGURE 24

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT ONE (0000 - 0559)

SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS



		NUMBER	PERCENT
NON-FREEWAY TRIPS		367	67.7%
TRIPS WITH FREEWAY SEGMENT(s)		175	32.3%
	TOTAL	542	

FIGURE 25

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT TWO (0600 - 0859)

SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

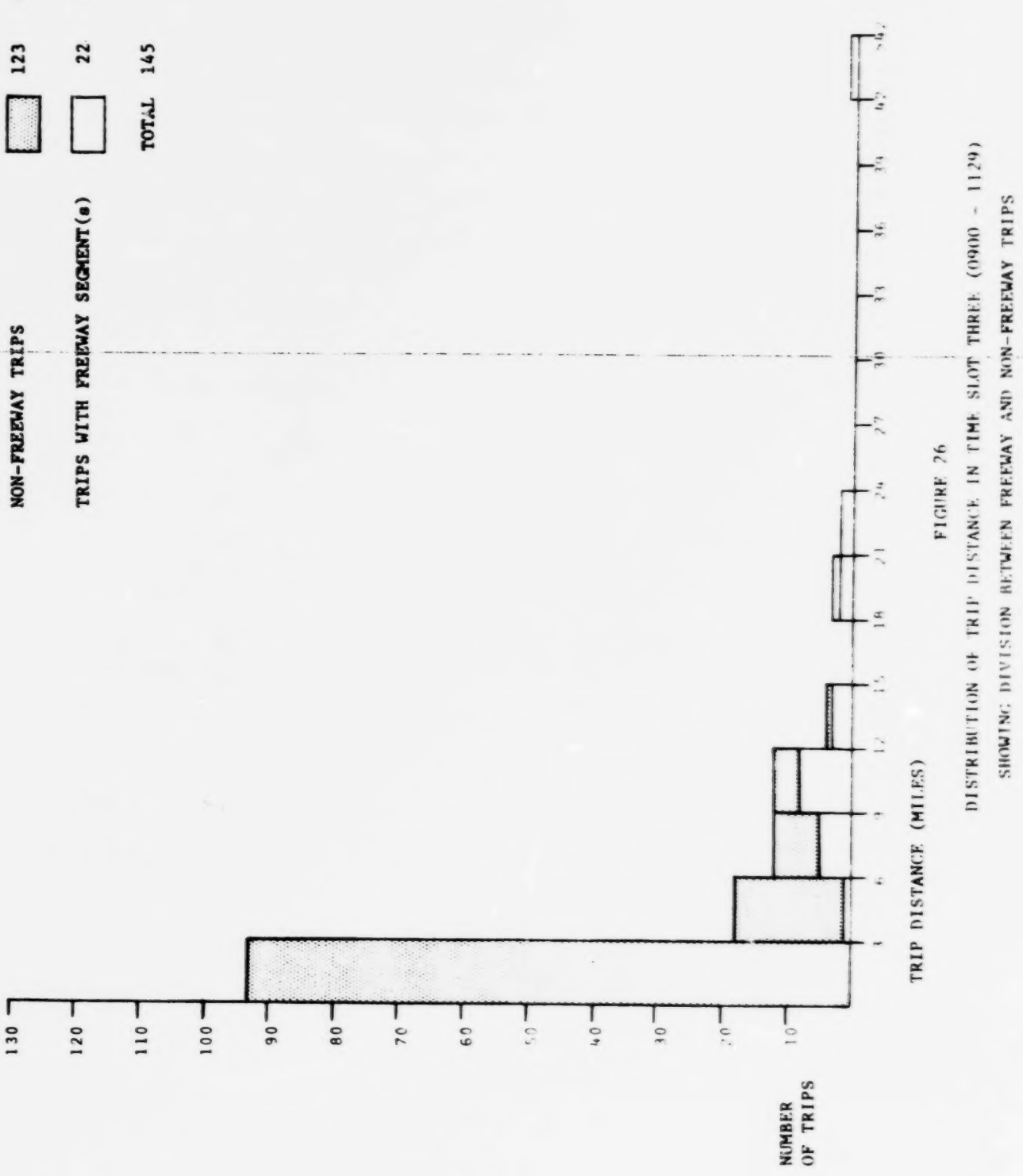


FIGURE 26

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT THREE (0900 - 1129)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

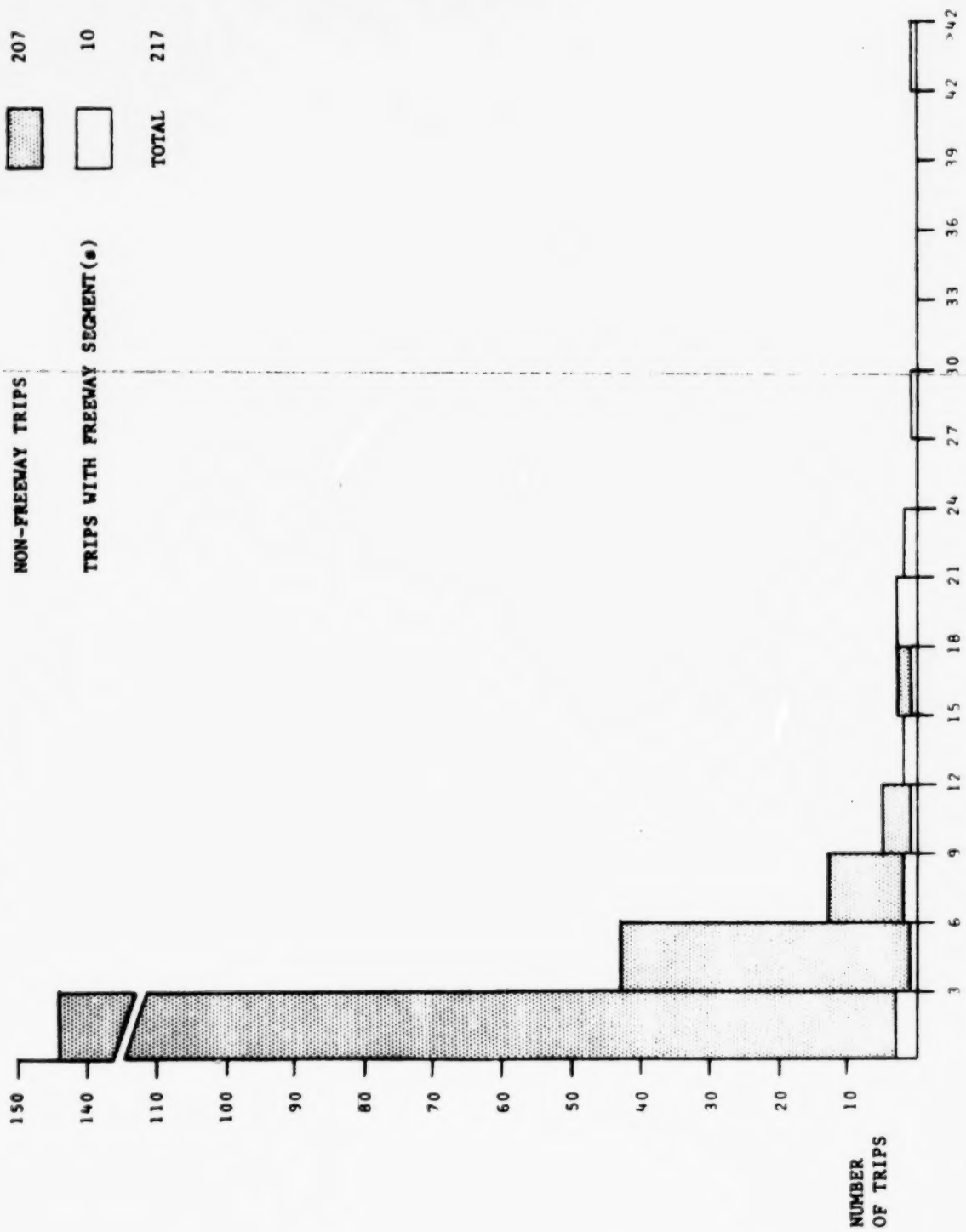


FIGURE 27

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT FOUR (1130 - 1329)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

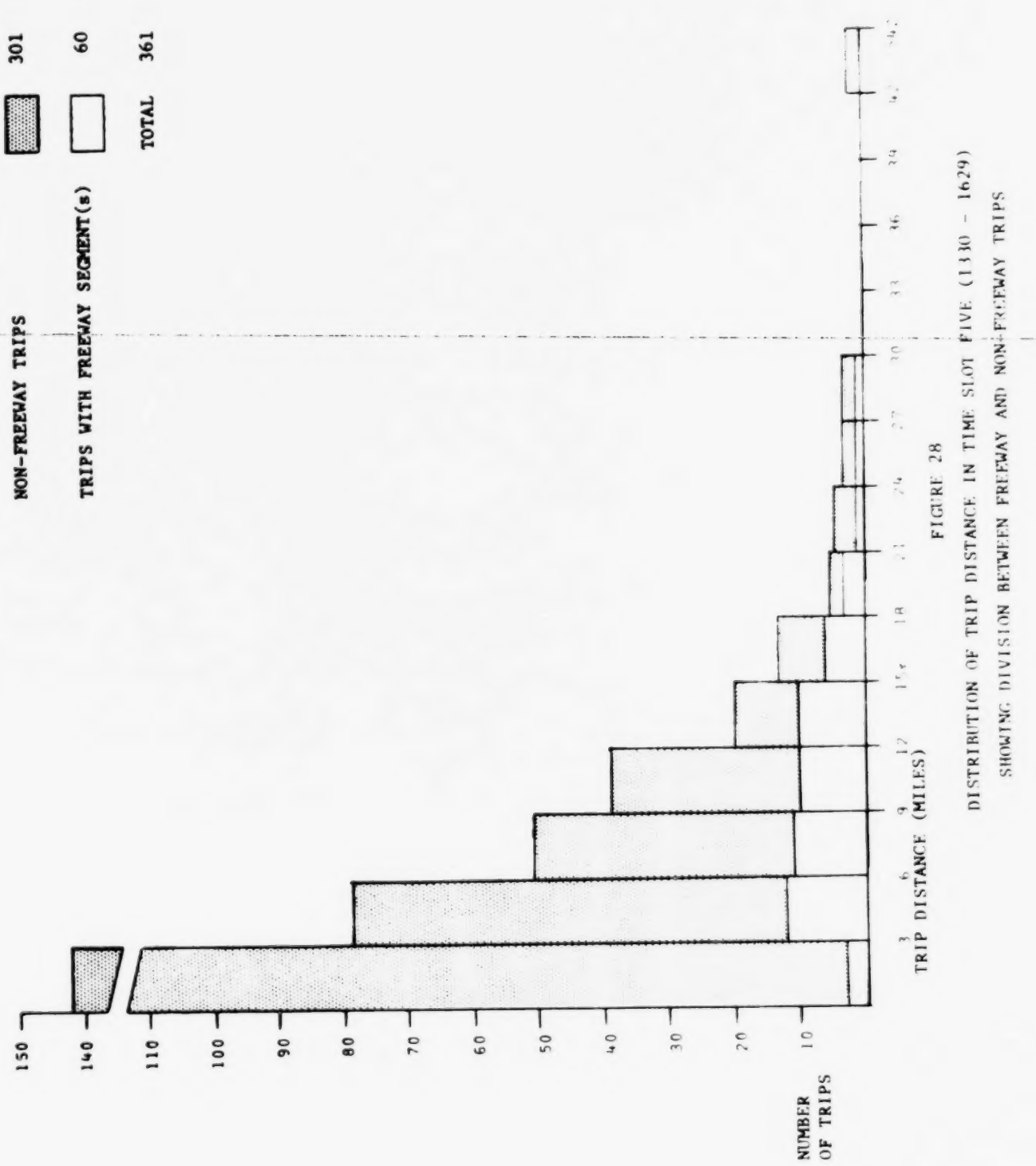


FIGURE 28

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT FIVE (1330 - 1629)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

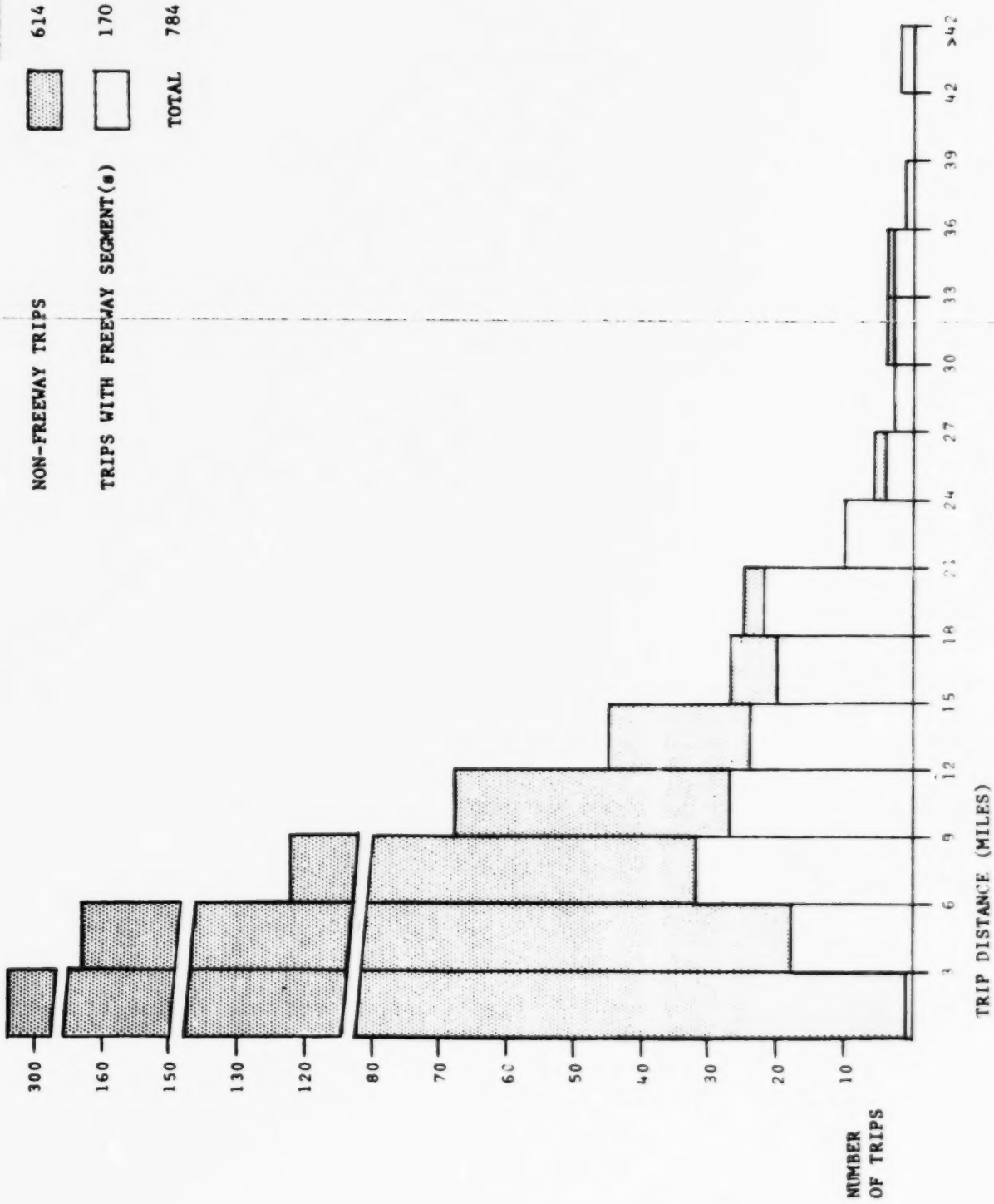
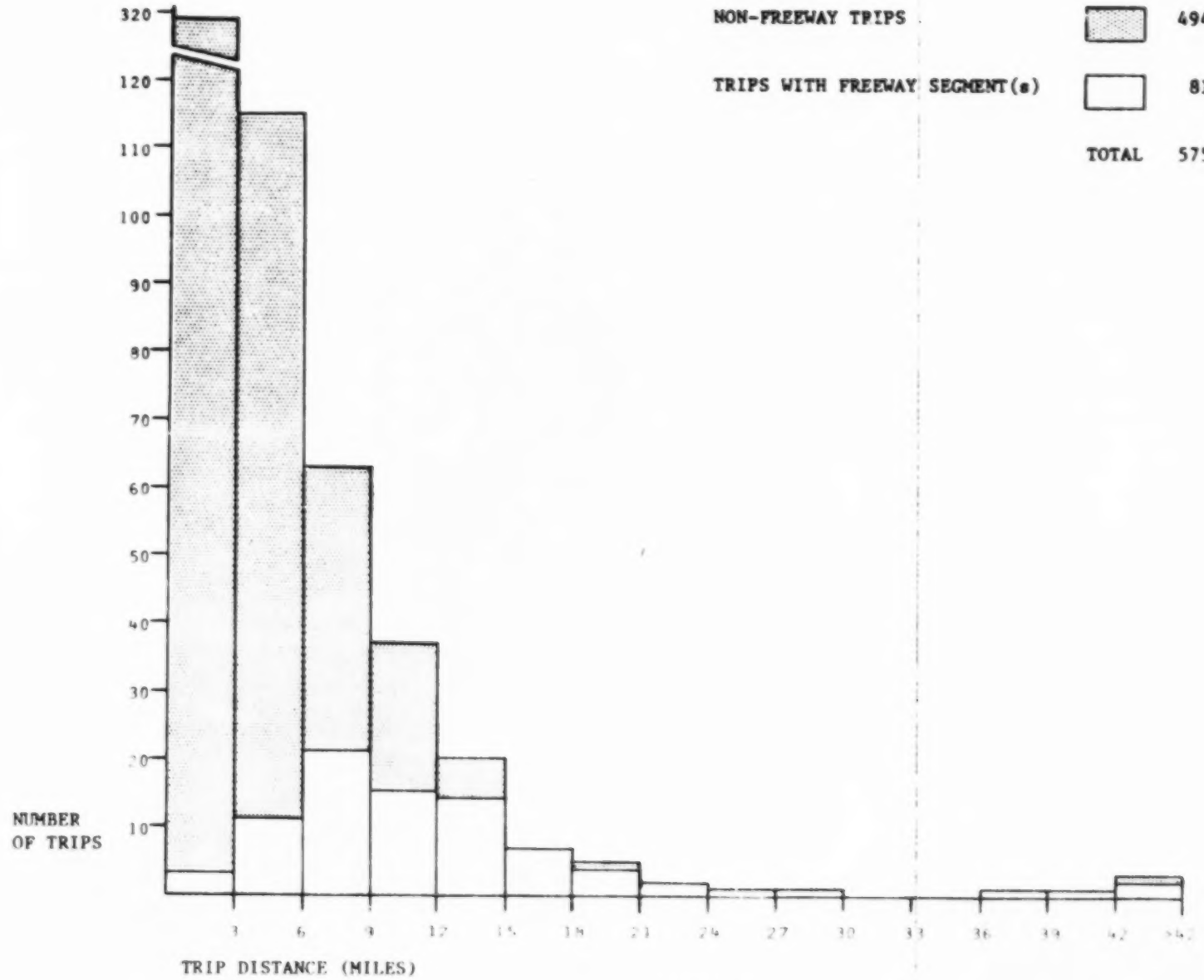


FIGURE 29

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT SIX (1630 - 1829)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS



		NUMBER	PERCENT
NON-FREEWAY TRIPS		494	85.9%
TRIPS WITH FREEWAY SEGMENT(s)		81	14.1%
	TOTAL	575	

FIGURE 30

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT SEVEN (1830 - 2059)

SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

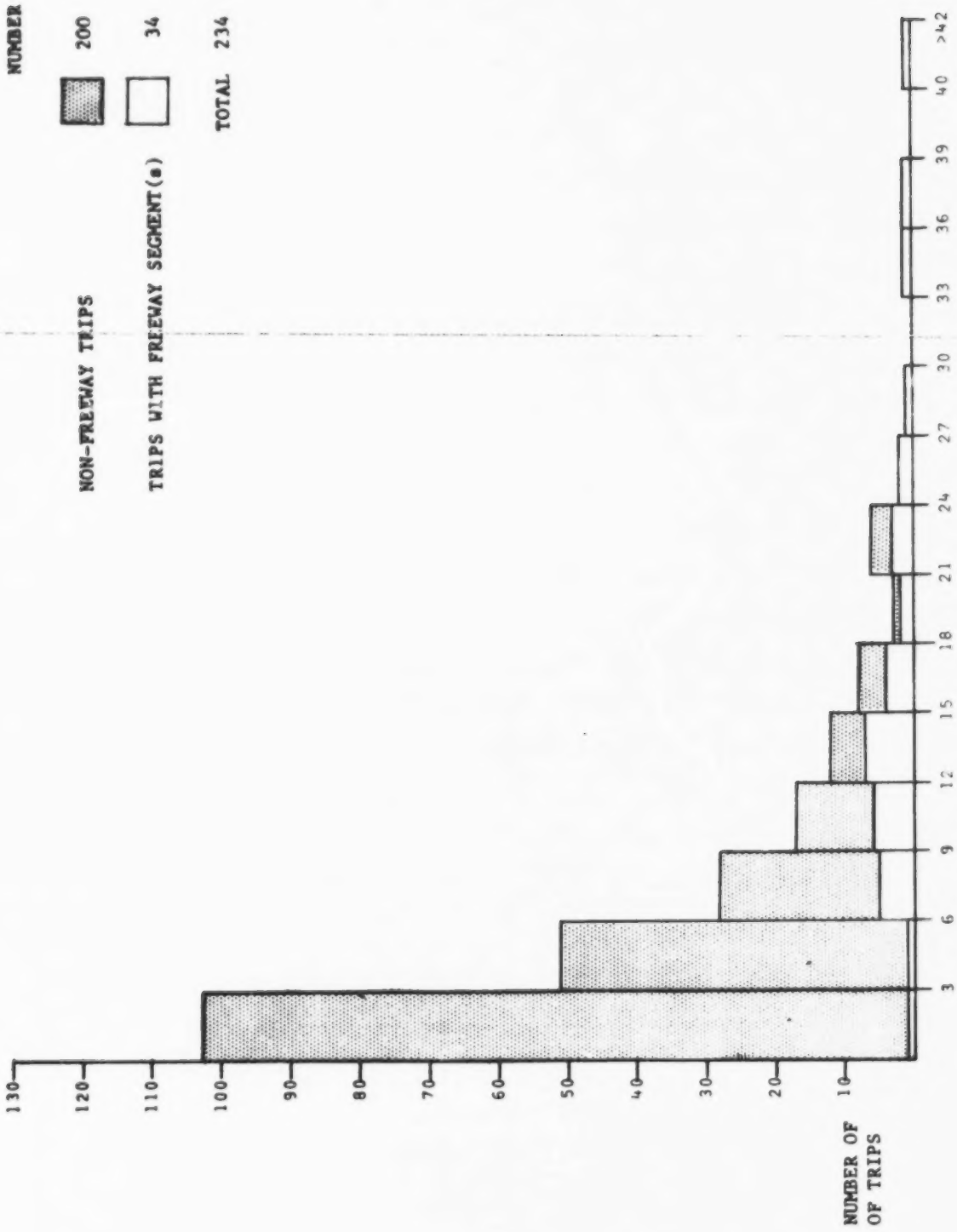

NUMBER PERCENT
NON-FREEWAY TRIPS 200 85.5%
TRIPS WITH FREEWAY SEGMENT(s) 34 14.5%
TOTAL 234
NUMBER OF TRIPS
TRIP DISTANCE (MILES)
3 6 9 12 15 18 21 24 27 30 33 36 39 40 >42

FIGURE 31

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT EIGHT (2100 - 2359)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

COMPARISON OF CINCINNATI, HOUSTON AND LOS ANGELES RESULTS

This section of the report compares the results obtained in the Cincinnati survey with those obtained in the Los Angeles and Houston surveys. It is divided into three discussion areas: n-trip day patterns, automobile utilization, and trip descriptors. The principal approach compares the frequency distributions of specific variables obtained in the samples of the three cities. Formally stated, the basic hypothesis being tested in each case is whether the three samples are drawn from populations that are homogeneous with respect to the variable being considered. Since the Driving Patterns Survey is concerned with the overall spectrum of driving characteristics rather than with the statistical averages that theoretically represent those statistics in some mathematical sense, we believe that the comparison of distributions provides a more valid basis for statistical inference than the comparison of sample means and standard deviations. Therefore, if statistical tests applied to three samples do not reject the hypothesis of nomogeneity, no further testing is carried out. If the hypothesis is rejected, then pairwise comparisons between the Cincinnati data and the data from each of the other two cities are made, testing the hypothesis that the Cincinnati results and those of the second city represent samples drawn from homogeneous populations. If, finally, these hypotheses are rejected, the data are examined to determine the reason for rejection and weaker (perhaps less relevant) hypotheses about the equality of sample means are made and tested. In all the statistical tests described, we used an α of 0.05. Thus, if a test indicates that a hypothesis should be rejected, the probability is only 0.05 that the test has rejected a valid hypothesis.

The comparisons of distributions for homogeneity employ the Kolmogorov-Smirnov statistic for variables with underlying distributions that are continuous and the Chi-Square Test of Homogeneity for Variables with discrete distributions. Other tests used for comparisons are described as they are used.

N-Trip Day Patterns

Table 41 shows the percentage of total n-trip days and total car-weekdays represented by those cars that drove the typical n-trip patterns. (In Volume 0, results for Los Angeles indicated n-trip pattern days as a percentage of total car-days. The values in Table 41 have been normalized to total car-weekdays to make them comparable to the Cincinnati and Houston results.)

TABLE 41

N-TRIP PATTERN CAR-DAYS AS A PERCENTAGE OF ALL N-TRIP DAYS AND ALL CAR-WEEKDAYS IN THE LOS ANGELES, HOUSTON AND CINCINNATI SURVEYS

N-TRIP PATTERN	PERCENT OF N-TRIP DAYS			PERCENT OF CAR-WEEKDAYS		
	LOS ANGELES	HOUSTON	CINCINNATI	LOS ANGELES	HOUSTON	CINCINNATI
2	44-54%	64-86%	44-57%	8.8-11.0%	13.5-18.1%	10.0-12.9%
3	18%	45%	28%	2.3%	5.0%	4.0%
4 (Evening)	12%	29%	30%	2.2%	5.3%	5.4%
4 (Noon)	13%	14%	8%	2.3%	2.7%	1.5%
5 (Evening-Shop)	16%	23%	22%	1.9%	3.1%	2.9%
5 (Work-Shop)	6%	0%	13%	0.0%	0.0%	1.8%

The results in Table 41 show that the percentage of typical n-trip pattern days in Cincinnati varies substantially from those in Los Angeles and Houston. All told, n-trip pattern days constitute 26% of the total Cincinnati car-weekdays as compared to the Los Angeles figure of 18% and the Houston figure of 30%. Chi-square tests of the homogeneity of the three cities with respect to n-trip pattern days as a percentage of total n-trip days as well as total car-weekdays reject the hypothesis of homogeneity for the three cities considered together. Pairwise tests indicate that Cincinnati and Houston can be considered homogeneous but that Cincinnati and Los Angeles are substantially different.

In the Houston report (Volume 1 of this series) we speculated on the possibility that seasonal differences in the length of daylight hours might be responsible for the difference in the number of typical n-trip pattern days between Los Angeles and Houston. This explanation is somewhat strengthened by the similarity that we find between Houston and Cincinnati. On the other hand, it is considerably weakened by the significantly greater proportion of trips in the night and early morning hours in Cincinnati. More interesting, however, is that the same patterns showed up (plus an additional one) in Cincinnati even though the time distribution of trips was statistically different from that in the other two cities.

Automobile Utilization

Automobile utilization is characterized by the number of trips driven per day, the times at which they are driven, their purpose, and the type of routes taken. The results of the survey in Cincinnati show that in most respects automobile utilization is significantly different, in the statistical sense, than in either Los Angeles or Houston.

The number of n-trip days (both weekdays and weekend days) in the three cities were compared by means of a chi-square test. The hypothesis of homogeneity was rejected at the $\alpha=0.05$ level but was not rejected at the $\alpha=0.01$ level. Pairwise tests showed that Cincinnati and Houston were considerably more similar than Cincinnati and Los Angeles with respect to the distribution of n-trip days. In all three cities, the frequency distribution curve shows the same general characteristics: distinct notches at one and three trips and a general dropping off after five trips. The maximum number of trips in all cities that we have surveyed has been 17.

A chi-square test of the division of trips between weekdays and weekend days in the three cities rejected the hypothesis of homogeneity. In Cincinnati there were proportionately more weekend trips than in either Los Angeles or Houston.

The time distribution of trips was tested first by time slot, then by the distribution of trip start times by 15-minute intervals throughout the day for both weekday and weekend trips. The time slot loadings in the three cities were tested with a chi-square test. For weekday trips, the hypothesis of homogeneity was rejected significantly. Similarly, chi-square tests also rejected the hypothesis for pairwise comparisons between Cincinnati and the other two cities. The reason here is that in Cincinnati a significantly larger proportion of trips was made in the evening time slots (1830-2359) than in the other two cities.

The time slot loading on weekends showed a significant difference between the three cities. Los Angeles and Cincinnati were the most similar pair. The chi-square test did not reject the hypothesis of homogeneity here if the α level was reduced to 0.01. The principal difference between the two cities was in the higher proportion of trips in time slot one in Cincinnati. A comparison of Cincinnati and Houston rejected the hypothesis of homogeneity significantly.

The three-city test of homogeneity with respect to trip start times by 15-minute intervals rejected the hypothesis for weekday trips. Pairwise tests similarly rejected the hypothesis in both cases. The rejection occurred because the cumulative distribution of trip start times in Cincinnati lags behind those for Los Angeles and Houston, the difference between them reaching a maximum in the interval between 1500 and 1515. After this, the greater number of evening trips in Cincinnati causes the distributions to equalize.

The Kolmogorov-Smirnov test on the distribution of trip start times on weekends in Houston and Los Angeles (reported in Volume 1) rejected the hypothesis of homogeneity. However, when the data for these two cities are pooled and compared to Cincinnati, the test does not reject the hypothesis of homogeneity. The Cincinnati distribution tends to lie midway between the distributions in the other two cities so that the overall three-city population does show a great similarity.

Tests on the distribution of trip purpose show significant differences in all cases but one. On weekdays, Cincinnati participants took proportionately more home, shopping and educational trips and proportionately fewer business, work and recreation trips than the Los Angeles and Houston participants. As a result, the overall chi-square test as well as the pairwise tests reject the hypothesis of homogeneity significantly. The overall three-way tests on the distribution of trip purpose for weekend trips reject the basic hypothesis significantly. This is because of the overall disparity between the three cities in the distribution of business trips and the differences between Los Angeles and Cincinnati with respect to educational trips (primarily church trips on weekends) and recreational trips. Cincinnati had considerably more of the former and less of the latter than Los Angeles. Pairwise comparisons in the case accentuate the difference between Los Angeles and Cincinnati but result in accepting the hypothesis of homogeneity between Houston and Cincinnati. In Volume 1 of this report we mentioned the possibility of driver interpretation affecting the purpose variable. However, the differences are so marked between Los Angeles and Cincinnati in the weekend case as to make it appear significant beyond the possibility of human differences being the cause.

Tests on the distribution of freeway versus nonfreeway trips in the three tests showed that the three cities do not by any means constitute homogeneous samples. Pairwise tests showed that even here homogeneity is lacking. The cause is that in Cincinnati there were fewer freeway trips of all types. The nonfreeway/freeway split on weekdays in Cincinnati was 80% nonfreeway and 20% freeway. This compares to a 68%/32% split in Los Angeles and a 70%/30% split in Houston. As mentioned earlier, the freeway system in Cincinnati at the time of the survey was incomplete and rudimentary. The two major freeways that do exist are connected. Therefore, there was a low incidence (1.3%) of trips with the configuration NFNFN. This contrasts sharply with the 5% of such trips in Houston where the freeway system still has substantial gaps even though it has more extensive coverage. In Los Angeles, where the freeways

present a higher developed and complete grid with substantial coverage, about 2% of the trips had the NFNFN configuration.

As in Los Angeles and Houston, the incidence of nonfreeway trips in Cincinnati increases on weekends. The nonfreeway/freeway ratio on weekends in Cincinnati was 86%/14%. This compares with 81%/19% in Los Angeles and 78%/22% in Houston. Again, statistical tests showed that the three cities were nonhomogeneous. Pairwise tests also failed to show homogeneity between Cincinnati and either of the other two cities.

Trip Descriptors

The pattern of statistically significant differences showing up in tests on the incidence of n-trip patterns and automobile utilization continues in tests on trip descriptors between Cincinnati, Los Angeles and Houston. The trip descriptors we will discuss are elapsed time between trips (soak times), trip distance, trip elapsed time, trip stops with engine running, and trip average speed. In addition, tests were made on the results of indoor-outdoor parking and overnight fuel tank readings.

A three-way test on the distribution of elapsed time between trips rejected the hypothesis of homogeneity for weekday trips but accepted it for weekend trips. The margin by which the weekday hypothesis was rejected was small. In pairwise comparisons for weekday trips the hypothesis was rejected for the Los Angeles-Cincinnati pair at α levels of 0.05 and 0.01. In the Houston-Cincinnati comparison, the test rejected the hypothesis at the α=0.05 level but accepted it at the α=0.01 level. In view of the importance of "soak time" to the problem of emissions, the continuing near-stability of the distribution of this variable would appear to be of considerable importance. This is particularly true since the frequency distribution of the variable is quite complex (see Figures 22 and 23).

A comparison of trip distance in the three cities rejected the hypothesis of homogeneity at the α levels of 0.05 and 0.01 for weekday trips but accepted the hypothesis of both α levels for weekend trips. The average weekday trip distance in Cincinnati was shorter by almost one mile than in Los Angeles and by almost two miles than in Houston. On weekends the total spread between average trip distances was almost 1.5 miles with Los Angeles having the smallest and Houston having the largest value. Calculations of the 95% confidence bands for the means in the three cities show that on weekdays the three bands are completely nonoverlapping. On weekends, the Cincinnati band contains the Los Angeles band but fails to overlap the Houston band. These comparisons were made with the distance distributions adjusted to remove values over 50 miles to allow more valid comparison with the Los Angeles band where these values had to be removed because of computer storage limitations.

Despite the fact that tests on the distributions of trip distance failed to show complete homogeneity, tests on the distributions of trip time showed considerably greater homogeneity. In the three-way test, the hypothesis was accepted for both weekday and weekend trips. Pairwise tests resulted in accepting the hypothesis for the Los Angeles-Cincinnati combination for both weekday and weekend trips but accepting it only for weekend trips in the Houston-Cincinnati combination. The 95% confidence level bands for the mean trip time in the three cities are overlapping for both weekday and weekend trips.

Tests of homogeneity with respect to the distribution of engine-on stops in the three cities rejected the hypothesis decisively in the across-the-board test as well as in pairwise combinations. This variable appears to be the most erratically distributed of any in the survey. Of course, it is dependent upon the degree of traffic congestion and presumably should be conditioned by the degree of freeway utilization. It is somewhat surprising, therefore, to see that Los Angeles seems to have the most stops per trip even though it has the greatest proportionate amount of freeway travel and an average trip

distance that lies midway between the other two cities, while Cincinnati has the fewest stops per trip while having the largest proportionate amount of nonfreeway travel and the shortest average trip distance.

Tests on the distribution of trip average speed accept the hypothesis of homogeneity between the three cities for weekend trips but not for weekday trips. Here all tests indicate that the overall average for trips in Cincinnati is slower by about one mile per hour. The 95% confidence bands for the means in the three cities show overlap between Los Angeles and Houston but show that Cincinnati lies outside the range of the other two cities. The same is true for the 99% confidence bands. Bartlett's test of the equality variances in the three cities also indicates a significant departure from hypothesis of equality. Therefore, from the standpoint of classical statistical tests, we must conclude that trips in Cincinnati are driven at slower average speeds than in the other two cities. However, the discussion in the next section of this part of the report deals with the possible shortcomings of these classical methods as they apply to the present study.

The distributions of indoor and outdoor parking in the three cities were tested twice, first for parking between trips and second for overnight parking. The hypothesis of homogeneity with respect to between-trip parking was rejected for both weekdays and weekends. The reason here was the prevalence of indoor parking in Cincinnati as compared to the other two cities, despite the fact that about 90% of all trips involved outdoor parking in all three cities. For overnight parking, the hypothesis of homogeneity was rejected for weekdays at the α level of 0.05 but was accepted at the α level of 0.005, indicating that the degree of departure from homogeneity was not great. The hypothesis was accepted for weekends at the α=0.05 level. The tendency in both cases was for more Cincinnati participants to park indoors overnight than did participants in the other two cities. In view of the low overnight temperatures in Cincinnati, this is not surprising.

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The final variable tested was the overnight fuel tank readings. For weekdays the hypothesis of homogeneity was rejected at the α=0.05 level and only barely rejected at the α=0.01 level, indicating only a small departure from homogeneity. On weekends, the hypothesis was again rejected at the α=0.05 level but here was accepted at the α=0.01 level.

Conclusions

The tests just described are all based on classical statistical techniques. In all cases the critical value of the test statistic is a function of sample size. The underlying theory in all of these tests is that the larger the sample size, the more "precise" the resulting comparison will be. In the case of the Driving Patterns Survey, sample sizes for all variables are large, whether based on number of trips or number of car days. Nevertheless, they are only finite samples from even larger populations. The number of trips per day in any of these samples constitutes only a miniscule percentage of the total number of trips taken on that day in the city being surveyed. Therefore, the degree of real precision in our results--that is, the degree to which our results are truly representative of the driving behavior of the city--depends crucially on how representative of the overall population the sample is. No measure of the degree of representativeness is available to us. To some extent, the real randomness of the sample must be an article of faith with the statistician in any survey and this holds true for the present study.

We stress this caveat because despite the number of tests described above where the three cities failed to show homogeneity, we do not believe that their failure to do so need necessarily mean that driving behavior is really significantly different in the three cities. If one examines the figures showing distributions of variables in the present and previous volumes from an essentially qualitative standpoint, one cannot help but be impressed by their overall similarity. There are no startling differences between the cities. This is perhaps the most significant finding of the study to date.

APPENDIX

CINCINNATI SURVEY PROCEDURES

The survey procedure was designed to obtain data from which typical driving patterns could be derived. Three basic steps were taken in the data gathering phase of the survey: design of the survey sample; selection of the survey participants; and collection of data. Subsequent sections of this Appendix cover each of these steps in detail.

SAMPLE DESIGN

The sample for the Cincinnati Driving Patterns Survey was designed to obtain data on an adequate number of trips to ensure that description of trip variables would be statistically accurate. Fifty Tachograph recording devices previously employed during the Los Angeles and Houston Driving Patterns Survey were used to collect data from fifty participating automobiles for one week; on the basis of Cincinnati's population, it was determined that data from 150 vehicles would be a representative sample.

As in the Los Angeles and Houston surveys, the sample was stratified four ways in terms of residence type (single family and multiple family dwelling) and car ownership (single car and multiple car). These stratification criteria were based on data from the continuing Los Angeles Regional Traffic Study (LARTS), which indicates that trip generation rates for automobiles can be correlated with residence type and car ownership.

The proposed stratification in Los Angeles was based on 1960 Census data. As the study there progressed, however, application forms from prospective participants showed clearly that the 1968 population had changed markedly from the 1960 population with respect to residence type and car ownership. This change necessitated a modification to the stratification of the Los Angeles sample.

Based upon our experience in Los Angeles relative to change in population, it was decided to stratify the sample for the Cincinnati survey according to data provided by application forms received from prospective participants. Percentages in each of the cells in the matrix in Table A-1 are representative averages of the information obtained from the 15 participating organizations in Cincinnati.

TABLE A-1

STRATIFICATION OF THE SAMPLE FOR THE CINCINNATI DRIVING PATTERNS SURVEY

RESIDENCE TYPE	AUTOMOBILES PER HOUSEHOLD	
	ONE	TWO OR MORE
Single Family	32%	47%
Multiple Family	17%	8%

PARTICIPANT SELECTION

The method by which SDC selected participants in the survey was chosen to obtain a representative cross-section of the Cincinnati population. A list of large industrial and commercial organizations in the area was provided by the Greater Cincinnati Chamber of Commerce. From this list 22 firms were contacted and briefed on the nature of the survey. Of the firms contacted, 15 agreed to participate.

Those companies that participated in the Cincinnati survey were Allis-Chalmers Manufacturing Company, Cincinnati Bell Telephone Company, Cincinnati Enquirer, Cincinnati Gas and Electric Company, Federated Department Stores, Formica Corporation, Keebler Company, Lodge and Shipley, Lunkenheimer Company, MacGregor Company, National Distillers Corporation, Nutone Company, Philip Carey Corporation, Procter and Gamble, and Union Central Life Insurance Company.

Individual volunteers from within each company were recruited by means of Information/Questionnaire Packets which were distributed among the employees (see Volume 0, Appendix II). All the organizations were encouraged to seek as many volunteers as possible; however, the number to be solicited as well as the method to be used to distribute the Information/Questionnaire Packets were left to the discretion of each organization. Generally, those organizations with smaller populations (85 to 500 people) chose to canvas all of their employees for volunteers; those with a larger population (more than 500 people) decided upon some form of random method of distribution, e.g., distribute one packet to every third name in the telephone book, distribute packets to all personnel who parked their automobiles in the company garage, etc.

A total of 3950 packets were distributed within the participating organizations. Of that number 546 individuals volunteered to participate, from which 181 met the stratification scheme and were chosen as the survey sample (see Table A-2).

DATA COLLECTION

The data collection effort in Cincinnati began on March 3, 1969. Of the 181 individuals chosen as the survey sample, 32 were eliminated for various reasons -- mechanical incompatibility between the volunteer's automobile and the Tachograph instrument, failure of individuals to report for the installation, mechanical condition of car, etc. Of the 149 actual installations made, 13 did not provide usable information because of mechanical failures either in the vehicle or the Tachograph.

TABLE A-2

RECRUITING PARTICIPANTS

ORGANIZATION	QUESTIONNAIRES DISTRIBUTED	VOLUNTEERS	SURVEY SAMPLE
Allis-Chalmers Manufacturing Company	200	77	20
Cincinnati Bell Telephone Company	200	141	20
Cincinnati Enquirer	200	54	10
Cincinnati Gas and Electric Company	400	21	10
Federated Department Stores	300	20	10
Formica Corporation	200	40	20
Keebler Company	100	8	5
Lodge and Shipley	100	19	10
Lunkenheimer Company	350	9	7
MacGregor Company	500	0	0
National Distillers Corporation	200	21	10
Nutone Company	200	48	20
Philip Carey Corporation	500	30	10
Procter and Gamble	200	44	20
Union Central Life Insurance Company	300	14	9
TOTALS	3950	546	181

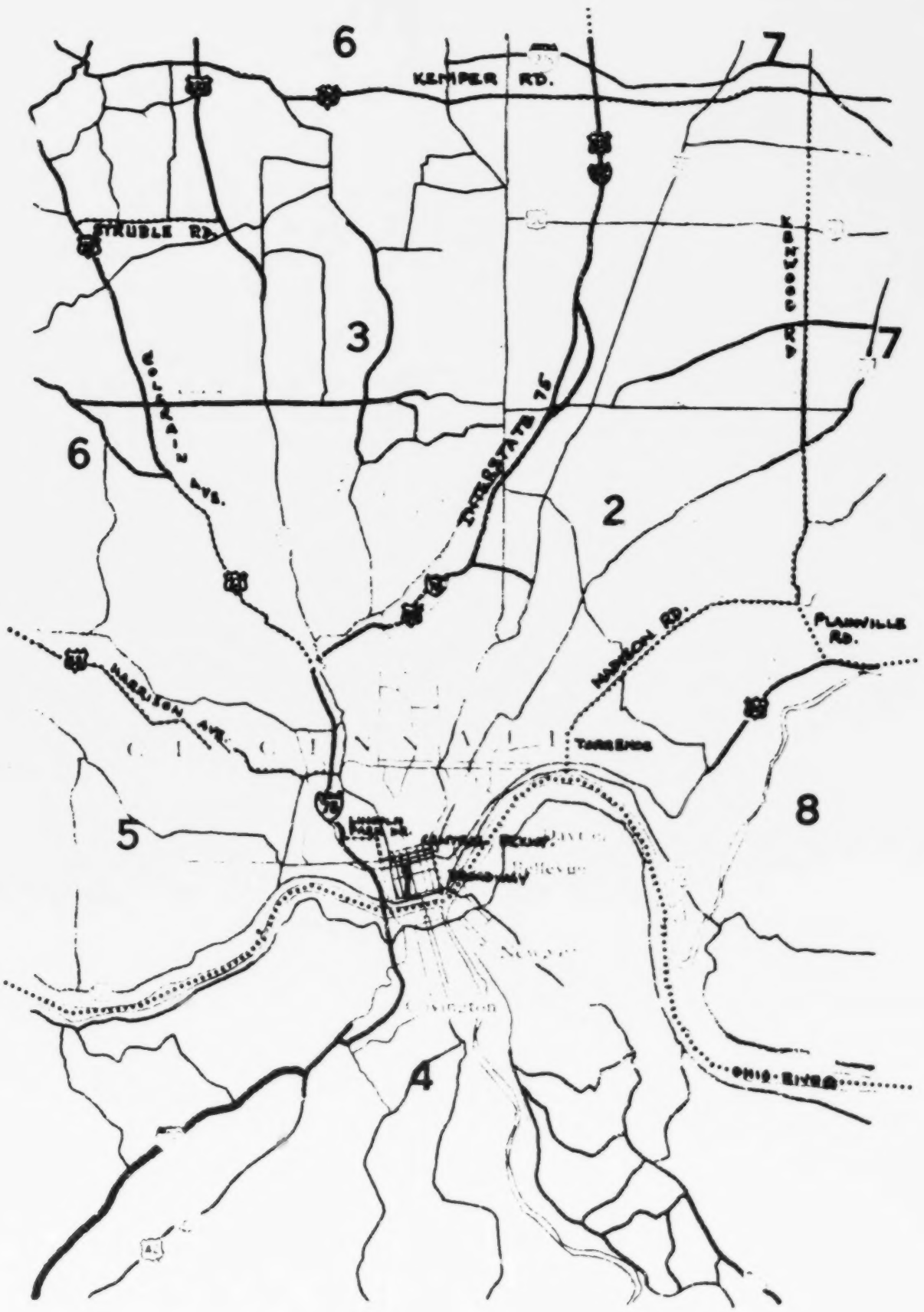

FIGURE A-1

CINCINNATI DRIVING PATTERNS SURVEY

SURVEY ZONES